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HUNTERS POINT
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HISTORICAL RADIOLOGICAL ASSESSMENT

HUNTERS POINT ANNEX

VOLUME I

NAVAL NUCLEAR PROPULSION PROGRAM

1966-1995

Radiological Control Office

Pearl Harbor Naval Shipyard
&
Intermediate Maintenance Facility

Pearl Harbor, Hawaii 96860-5350

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1.0 EXECUTIVE SUMMARY

1.1 Purpose

This Historical Radiological Assessment (HRA) has been prepared by Pearl Harbor Naval Shipyard & Intermediate Maintenance Facility for Hunters Point Annex (HPA) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). The purpose of this HRA is to catalog and present over 29 years of radiological environmental data within the framework of the CERCLA process and within the pathway scoring protocol of the revised Hazard Ranking System (HRS).

Volume I of this HRA addresses radioactivity associated with the Naval Nuclear Propulsion Program (NNPP). Volume II addresses general radioactive material (G-RAM), including all non-NNPP applications of radioactivity (both Radiological Affairs Support Program (RASP) material and any site-related medical applications). Different branches of the Navy are responsible for these categories of radioactivity, and different historical practices have applied.

1.2 Background

From 1966 to 1973, HPA was occasionally used as a berthing and drydocking facility for Navy nuclear-powered ships. Between 1985 and 1989, Mare Island Naval Shipyard (MINS) performed emergent or short restricted availabilities on nuclear-powered cruisers and aircraft carriers in Drydock 4, including limited component and external hull work.

Drydock 4 at HPA was utilized because of its ability to accommodate the larger ships and its location near the deeper waters leading into HPA. This drydock was used a total of five times to support work on Naval nuclear-powered ships.

Beginning in 1966, the year nuclear-powered surface ships began berthing across the bay at Naval Air Station Alameda, MINS commenced radiological environmental monitoring of HPA. Radiological environmental monitoring by MINS continued until the first half of 1995. Results were forwarded to the NNPP headquarters which, since 1966, has published an annual report with distribution to other Federal agencies, states, Congress, and the public.

Independent cross-checks of analytical results and an independent survey of the harbor by the Environmental Protection Agency have been an integral part of this program since its inception. These independent verifications have been consistent with NNPP results and conclusions.

1.3 **Findings**

Since 1978, when improved equipment permitted specific radionuclide analyses, no radioactivity associated with the Naval Nuclear Propulsion Program has been detected in any sediment, harbor water, marine life, or harbor core samples. Of all the radiological data collected by the shipyard and the Environmental Protection Agency (EPA), no radioactivity associated with the NNPP has been detected in environmental samples. This has been confirmed by the findings and conclusions of the EPA survey performed in 1986, reported in 1989, and quoted in Section 6.1.1 of this HRA. Controls for the prevention of release of radioactivity to the air, soil, and ground water pathways, and immediate control and remediation of inadvertent releases to these pathways, have been in place from the beginning of NNPP work.

HPA was designated for closure by the 1991 Base Realignment and Closure Commission. This recommendation was adopted and became law on September 27, 1991. After the final nuclear-powered ship drydocking in 1989, a radiological survey plan was implemented to identify any remaining radioactivity associated with the Naval Nuclear Propulsion Program. No NNPP areas were found to require remediation.

1.4 **Conclusions**

This HRA concludes that: (a) the berthing of and work on nuclear-powered ships at Hunters Point Annex has had no adverse effect on the human population or the environment of the region; and (b) an independent review by the Environmental Protection Agency is consistent with these conclusions. The Navy concludes that no additional characterization and no remedial actions are necessary as a result of NNPP activities at Hunters Point Annex.

2.0 INTRODUCTION

2.1 Background

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established a process whereby past private sector disposal sites were scored for environmental contamination, and remedial action would be initiated where warranted. Federal facilities were not included within CERCLA; however, under Executive Order 12316 of August 20, 1981, the President directed the Department of Defense (DOD) to conduct similar evaluations of their installations.

By the mid-1980s, most DOD facilities had been evaluated. These Initial Assessment Studies were conducted for Naval shipyards and operating bases where nuclear-powered ships were maintained and berthed. The Hunters Point Naval Shipyard Initial Assessment Study (Reference 1) was completed in 1984.

During 1986, DOD realigned its programs to be more consistent with those of the Environmental Protection Agency (EPA) in the private sector. Initial Assessment Studies paralleled the Preliminary Assessments and Site Inspections of CERCLA. Confirmation Studies paralleled the Remedial Investigation and Feasibility Studies of CERCLA.

The Superfund Amendments and Reauthorization Act (SARA) of 1986 required that Federal agencies comply in the same manner and extent as private entities, and allowed Federal activities to be placed on the National Priorities List (NPL). Executive Order 12580 of January 23, 1987 gave additional jurisdiction to the EPA for Federal facilities on the NPL.

SARA also directed the EPA to revise its Hazard Ranking System (HRS) used to score sites undergoing the CERCLA process. This was completed and the revised HRS was published in the Federal Register in December 1990.

The EPA scored Hunters Point Annex (HPA) under the original HRS in 1988. Data collected during the 1984 Initial Assessment Study, Reference 1, was used in this scoring. Due to past chemical disposal and control practices, HPA was placed on the NPL in 1989. The 1984 Initial Assessment Study did not include consideration of any past releases of radioactivity associated with Naval Nuclear Propulsion Program (NNPP) work, since its emphasis was on industrial and chemical pollutants. A Federal Facilities Agreement (FFA) was signed on January 22, 1992, between the Navy, EPA, and the State of California, which established cleanup actions and time frames. An interim amendment FFA was signed in May 1993, and negotiations were begun for a final FFA. FFA schedules have since been revised.

Between 1992 and 1995, HPA and its off-shore area was divided into six parcels to facilitate environmental investigation and cleanup.

2.2 **Purpose**

This Historical Radiological Assessment (HRA) was produced to provide a comprehensive review and assessment of the impact of radiological operations at HPA. This assessment is organized in a format similar to the standard Preliminary Assessment (PA) protocol used by the EPA within the CERCLA process. This format was chosen as a vehicle that is in common use and is easily understood.

Environmental radiological data collected for HPA is catalogued and presented within the pathway evaluation protocol of the PA. Additional environmental data collected by the EPA and their independent conclusions, are included in the relevant sections of this assessment.

Section 8 of this assessment addresses each pathway along with the salient data results contained in previous sections and evaluates estimates of radiological impact to the public and to the environment from operations at HPA.

This assessment is historical in that the regulatory and policy changes that have occurred during the evolution of the NNPP are included as an explanatory supplement to the analytical results.

2.3 **Methods**

2.3.1 **Counting Terminology**

"Gross gamma" spectrometry systems used for counting environmental samples are currently calibrated to respond to gamma energies between 0.1 MeV and 2.1 MeV, and thus detect a combined total of all radionuclides with gamma energies between 0.1 and 2.1 MeV. (The gross gamma energy range for counting systems used from 1966 through 1974 was between 0.6 and 1.6 MeV.) Similarly, "cobalt-60 energy range" gamma spectrometry is used to identify total gamma radioactivity in the range of 1.1 to 1.4 MeV. Where activity in this range is above 1 pCi/g, detailed radionuclide analysis is performed to determine whether cobalt-60 is present or whether all the activity is due to other (natural or fallout-related) radionuclides. For some analyses (e.g., modern environmental monitoring sediment, water, and biota samples), detailed radionuclide analysis is performed regardless of measured gamma levels.

Spectrometry detectors, whether sodium iodide or germanium, have conversion efficiencies which vary as a function of the incident gamma energy. This means that in order to determine the amount of a given radionuclide in a sample, the efficiency of the detector for that specific radionuclide would have to be determined using a known source of that radionuclide. Alternatively, a source containing known quantities of several radionuclides with gamma energies ranging from about 0.15 MeV to about 2.0 MeV can be used to construct an efficiency curve for the detector.

A simpler approach is to assign the efficiency for a particular radionuclide to all energies between the upper and lower limits of the region of interest. For the NNPP, cobalt-60 is the most predominant radionuclide and has the most restrictive concentration limit in air and water of all the radionuclides identified in Naval reactor plants. If all of the radionuclides with gammas occurring within a given band of energies are quantified by using the efficiency of the most limiting radionuclide, the resulting calculated quantity will conservatively overestimate the actual radioactivity for the radionuclide of concern.

Gross gamma, cobalt-60 equivalent is the quantity of all radioactivity in the gamma energy range of interest (0.1 - 2.1 MeV) calculated using the efficiency value of cobalt-60. Cobalt-60 energy range radioactivity is calculated using the cobalt-60 efficiency for all energies between 1.1 MeV and 1.4 MeV.

Natural background radionuclides generally have only one gamma per disintegration, of lower energy than cobalt-60's two gammas (potassium-40 is an exception). Hence, actual background radioactivity is likely higher than that measured and reported by this procedure. This is acceptable since background radioactivity is not of concern in these "gross gamma" and "cobalt-60 energy range" measurements. (This is also the basis for the term "cobalt-60 equivalent activity," since instruments are calibrated for pure cobalt-60 activity.)

When detailed radionuclide analyses are performed, germanium detectors are used. "Actual cobalt-60 radioactivity" or "specific cobalt-60" is the amount of cobalt-60 only, based on the counts in the 1.33 MeV photopeak and the efficiency of the detector at that photopeak using a known cobalt-60 source in a geometry equivalent to that of the sample.

2.3.2 **The Investigatory Process**

The pathways, targets, and potential release mechanisms described in this HRA were used to guide the process of selecting the information to be reviewed in preparing this assessment. During the course of the investigation, they were used to gauge the adequacy of the historical record of radiological work at HPA.

Information descriptive of HPA was in large measure taken from recent Navy Installation Restoration documents. Navy and HPA correspondence and history files were reviewed to ensure all potential source terms of radioactivity were identified. Historical records were reviewed to ensure that an accurate account is presented of past requirements and practices.

All available records related to release, monitoring, and waste disposal were reviewed to determine: where radiological work was performed; what the environmental impact of radiological operations has been; and the history of radioactive waste disposal. Records were reviewed to determine if any inadvertent releases of radioactivity to the environment were not immediately remediated. Records of areas formerly used for radiological work were reviewed to determine whether all such areas have been appropriately released from radiological controls in accordance with all applicable requirements. A more detailed discussion of the specific types of records reviewed, and the results of that review, are contained in Section 5.

2.3.3 **Interviews**

Interviews with about a dozen long-term and previous employees were conducted to examine whether the body of documented records is complete. These included workers who were involved in nuclear operations such as former shipyard Radiological Control Division employees, nuclear engineers, and managers (less formal interviews were initially conducted with Radiological Control Division Heads and senior Nuclear Managers to obtain names of more knowledgeable, "old-timer" candidates for formal, detailed interviews). Formal interviews consisted of face-to-face discussions. Prior to asking specific questions, the purpose of the interview and a brief background on the HRA was given to the interviewee. Topics discussed during the interview included the former employee's position, responsibilities, periods of employment, and involvement in selected elements applicable to the HRA. The former employee was specifically questioned if any environmental releases had occurred that were not documented in the HRA, whether any disposal of radioactive material had occurred on-site, and whether any radiological practices documented by historical records forming the basis of this HRA had changed. No cases of unreported environmental releases of radioactivity or unauthorized disposal of radioactive material were identified, nor were any past radiological practices reported to be different from those documented in this HRA.

2.3.4 **Units**

Units used throughout this report include: pCi/100 cm^2 (picocurie per 100 centimeters squared), pCi/g (picocurie per gram), kcpm (thousand counts per minute), µCi/ml (microcurie per milliliter), Ci/yr (Curie per year), mrem/qtr (millirem per quarter year), and µR/hr (microroentgen per hour). A further explanation of a particular unit can be found in the glossary.

3.0 SITE DESCRIPTION

3.1 Site Name and Location

Hunters Point Annex (Disestablished)
San Francisco, California
EPA Region IX
CERCLIS ID#: CA1170090087

Information for this section was obtained from References 1 through 5.

The site of Hunters Point Annex (HPA) lies entirely within the corporate boundaries of the City of San Francisco, California, near its southern boundary with San Mateo County. HPA is located on San Francisco Bay, at the southeast corner of the city of San Francisco. The site is on the point of a high, rocky, two-mile long peninsula which projects southeastward into the bay.

Drydock 4 of HPA, where nuclear-powered ships were docked, is located at approximately 37°43'25" North latitude and 122°21'40" West longitude. Figure 3.1 is a copy of four spliced 7.5 minute quadrangle maps, for the San Francisco North, Oakland West, Hunters Point, and San Francisco South quadrangles. Hunters Point is clearly designated. Circles of 1/4, 1/2, 1, 2, 3, and 4 mile radii are shown, using Drydock 4 as origin.

Figure 3.2 is a vicinity map of HPA. Figures 3.3 (a)-(e) are historical photographs of HPA, presenting the shipyard before and after construction of Drydock 4. Figure 3.4 is a drawing of HPA with identifying building numbers, pier and berth designations, etc.

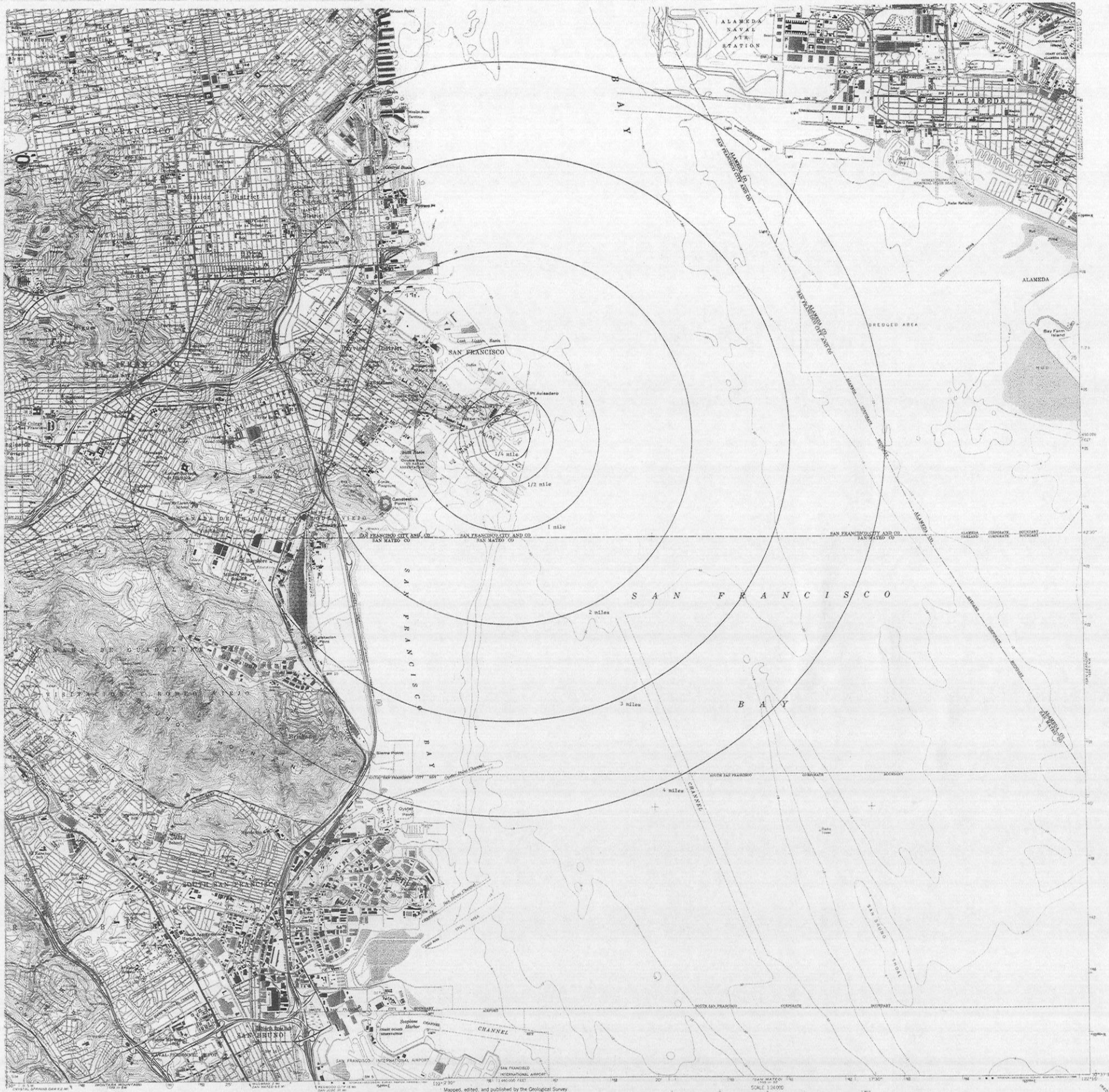


Figure 3.1
Hunters Point Annex
with Distance Zones

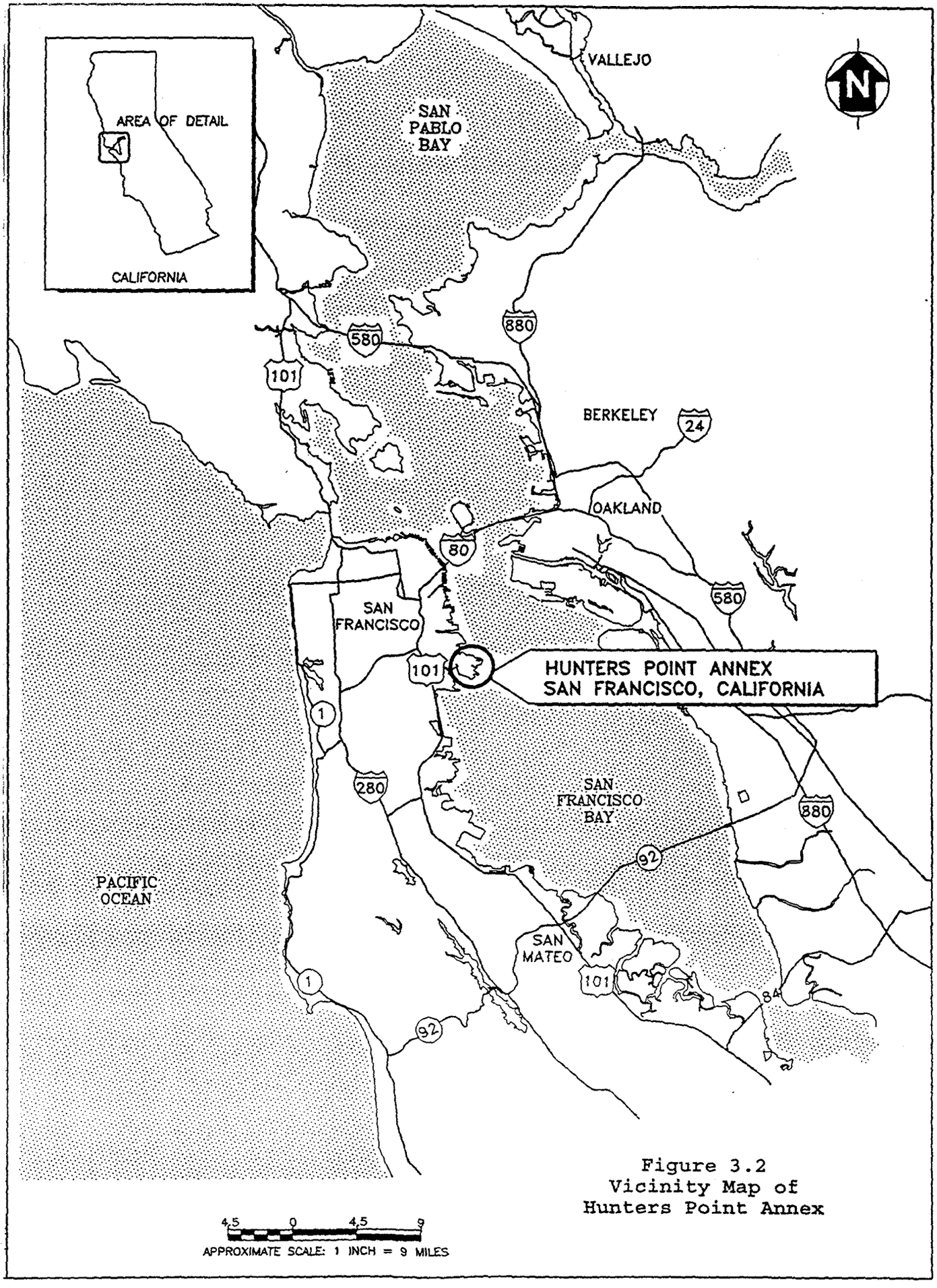


Figure 3.2
Vicinity Map of
Hunters Point Annex

U.S. NAVAL DRYDOCKS
HUNTERS POINT
1942

Figure 3.3 (a)

Figure 3.3 (b)

SAN FRANCISCO NAVAL SHIPYARD

1951

Figure 3.3 (c)

SAN FRANCISCO NAVAL SHIPYARD
1962

Figure 3.3 (d)

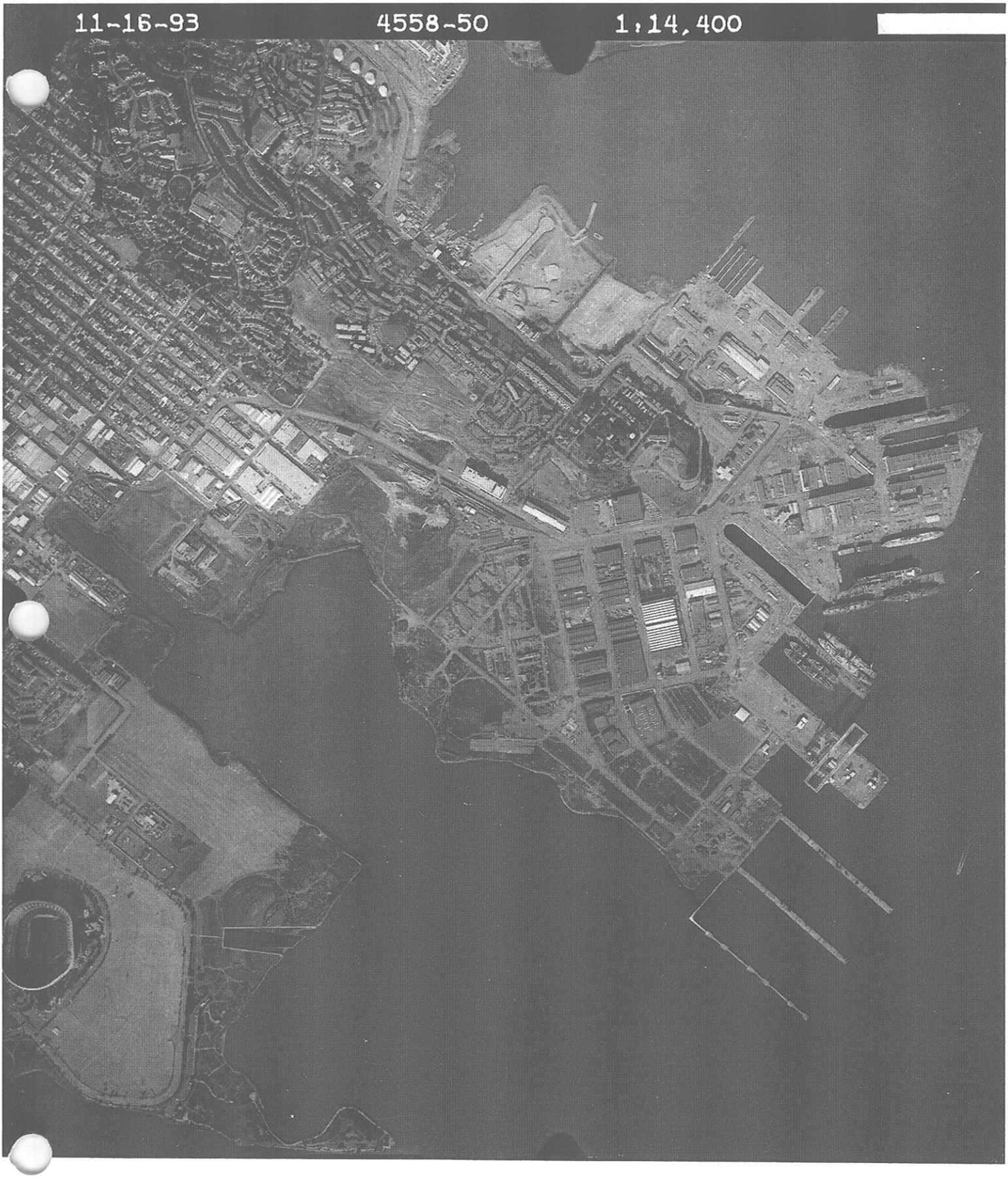


Figure 3.3 (e)

Figure 3.3 (f)
Drydock 4
Hunters Point Annex
(1997)

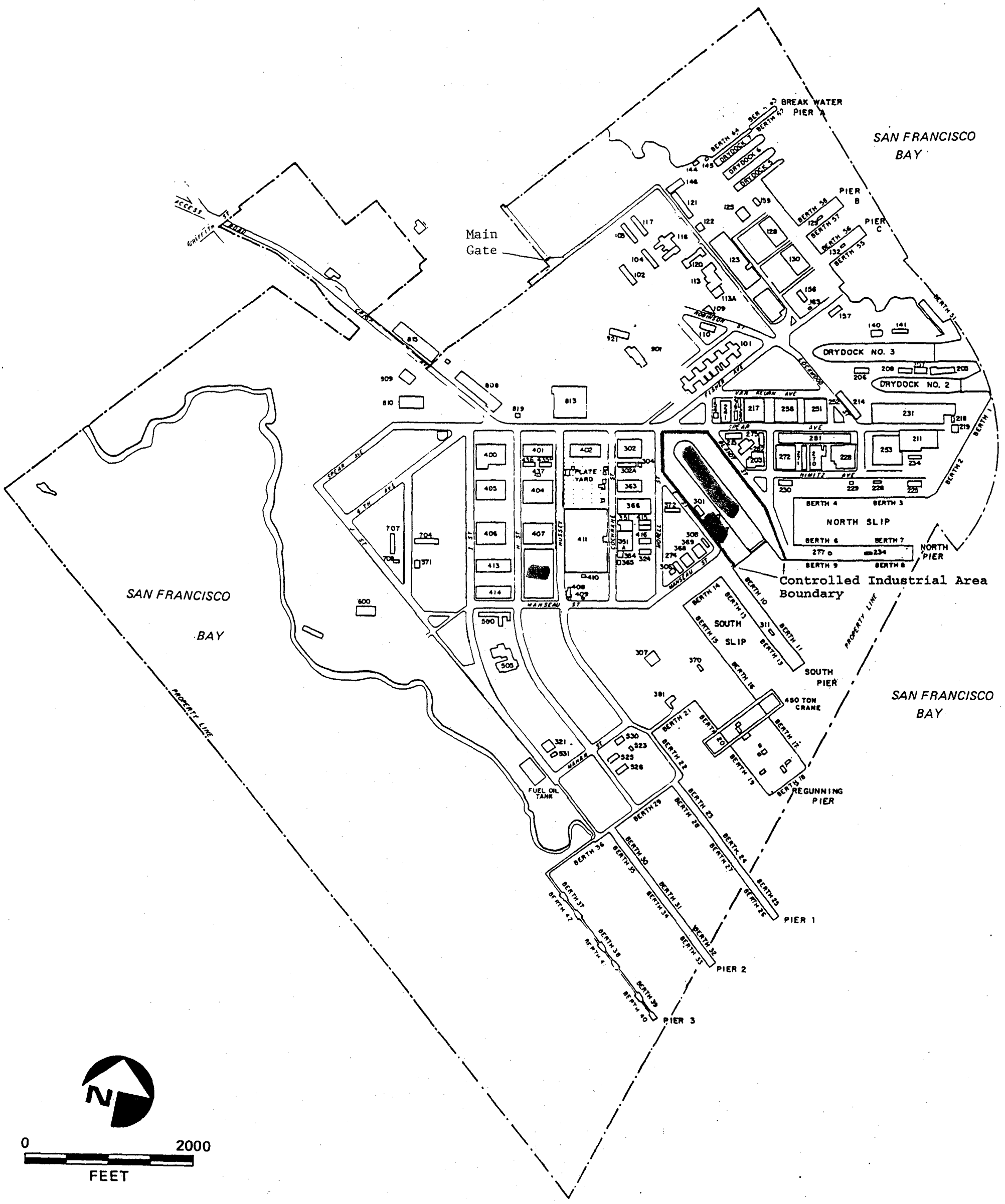


Figure 3.4
Hunters Point Annex
Site Map

3.2 Site History

3.2.1 Type of Site

Naval operations at Hunters Point Annex (HPA) began in 1941, near the start of World War II. From 1941 until 1994, the principal facility activities were ship building and modification, repair, and maintenance of ships and submarines. The facility was also used for base housing, naval ordnance training, radiological defense research, and research on exposure to radioactive fallout.

HPA was comprised of three functional areas:

- Basic industrial production area at the northern and eastern portions of the site, including the waterfront and shop facilities of the different industrial groups.
- Industrial support area at the central and southwestern portions of the site, including supply and public works facilities.
- Non-industrial area at the northwestern and southern portions of the site, including Naval personnel support facilities such as barracks, officer quarters, and recreation areas.

During its operation, HPA occupied 964.91 acres, of which 54.58 acres were used for housing and other non-industrial activities.

3.2.2 Navy Ownership History

The peninsula upon which the shipyard was established was originally known as La Punta de Concha (Sea Shell Point), and later as Point Avisadero (Beacon Point). During the 1849 "Gold Rush" period, the site became the home of Robert and Phillip Hunter, and subsequently acquired the name Hunters Point.

In 1869, the first commercial drydock on the West Coast was established on the site by the California Drydock Company.

During their round-the-world cruise in 1907-1908, 23 vessels of the "Great White Fleet" were serviced at Hunters Point due to insufficient depth of the channel to the Navy facilities at Mare Island.

In 1916, the Navy recognized the importance of this privately-owned deep water drydocking facility and subsidized the construction of a third drydock on the site of the existing Drydock 1. Drydock 3 was completed and first used by the Navy in 1919. The drydocks served all large deep draft vessels in San Francisco Bay until international tensions influenced the Navy to purchase the drydocks in December 1939.

In 1940, the U.S. Government received title to the land at Hunters Point. Of the property acquired, Drydocks 2 and 3, two pumphouses, a boilerhouse, a gatehouse, and a paint storage building currently form a historic district. These buildings meet the requirements for placement on the National Register of Historic Places.

The Navy leased the drydocks to Bethlehem Steel Company until December 1941, and then developed the Hunters Point Naval Drydock as an annex to the Navy Yard at Mare Island. In 1943, Drydock 4 was added, and in 1944, the submarine overhaul facilities along with Drydocks 5, 6, and 7 were completed.

The site's workforce grew to almost 18,000 by the end of World War II. To accommodate the influx of workers, neighboring hillsides were carved for construction of temporary apartments, roads were constructed to connect the housing areas to the shipyard, and a railroad right-of-way was acquired.

In November 1945, the Radiological Safety Section (RSS) originated at Hunters Point as part of the San Francisco Naval Shipyard Industrial Laboratory. In 1948, the RSS was renamed the U.S. Naval Radiological Defense Laboratory (NRDL). NRDL became a separate command of the shipyard in 1950 and operated until 1969. From 1945 until 1969, NRDL arranged for the decontamination and disposition of ships involved in nuclear weapons tests in the Pacific. The mission of NRDL was the study of nuclear weapons effects and the development of countermeasures.

In December 1945, the site was designated as a separate Naval Shipyard and, as San Francisco Naval Shipyard, became increasingly diversified as a major fleet logistic support facility. Beginning with the conflict in Korea in 1950, the shipyard was again actively involved in ship repair.

By 1951, the shipyard shifted from operating as a general repair facility and began to specialize in submarine repair. The shipyard also continued to overhaul aircraft carriers and other ships.

In April 1965, the San Francisco Naval Shipyard Command and Mare Island Naval Shipyard Command merged to form the San Francisco Bay Naval Shipyard. The shipyard facility at Hunters Point became an industrial annex of the San Francisco Bay Naval Shipyard. The Navy operated the shipyard as an aircraft carrier and ship repair facility through the late-1960s. The workload consisted primarily of repair and conversion of conventionally-powered surface ships, repair of diesel submarines, and non-radiological work on nuclear-powered ships.

In January 1970, the San Francisco Bay Naval Shipyard divided into Hunters Point Naval Shipyard and Mare Island Naval Shipyard.

In April 1973, the Secretary of Defense announced that the Hunters Point Naval Shipyard would be closed on June 30, 1974 as part of the Department of Defense Shore Establishment Realignment Program. Plans for leasing the shipyard were made during the spring and summer of 1974. In late 1975, all shipyard property was assigned to the Office of the Supervisor of Shipbuilding, Conversion, and Repair, San Francisco.

In May 1976, the Assistant Secretary of the Navy authorized the lease of the shipyard to Triple A Machine Shop Incorporated, a commercial ship repair firm. Triple A leased more than 80 percent of the shipyard for repair of commercial and Naval vessels and subleased unused facilities to private warehousing, industrial, and commercial firms. The lease expired in 1986, and Triple A vacated the site in March 1987. Extensive litigation between Triple A and the City of San Francisco, regarding storage and disposal of non-radiological hazardous waste at Hunters Point, resulted in the investigation of numerous disposal sites.

In 1986, the shipyard was taken over by the Navy to be developed as an annex to Naval Station Treasure Island, and many of Triple A's tenants acquired leases with the Navy. From November 1985 to August 1989, the docking and repair of several Navy surface ships took place at the shipyard, including nuclear-powered cruisers. In 1990, the shipyard came under the jurisdiction of Naval Station Treasure Island.

In 1991, the Department of Defense designated Hunters Point Annex (HPA) for closure pursuant to the Base Closure and Realignment Act. In March of 1994, control of HPA was transferred to Naval Facilities Engineering Command, Western Division (now Engineering Field Activity West), located in San Bruno, California. In 1996, HPA was renamed Hunters Point Shipyard (HPS); while it has also been referred to as Hunters Point Naval Shipyard (HPNS), the name Hunters Point Annex remains in most common use.

Many of the facility buildings have been leased to private tenants and Navy-related entities for maritime and nonmaritime industrial and artistic purposes. Property use includes storage, art studios, machine workshops, woodworking shops, auto restoration garages, recreational vehicle parking, and filming of movies.

3.2.3 **Site Activities**

HPA was a large industrial complex capable of providing the full range of industrial, manufacturing, and technological processes required for overhauling and repairing the modern high technology warships of the U.S. Navy.

In the specific case of Naval Nuclear Propulsion Program work, which is the focus of Volume I of this HRA, all of the engineering disciplines, trade skills, quality assurance inspectors, and radiological control personnel were available from Mare Island Naval Shipyard (MINS), and occasionally Puget Sound Naval Shipyard, to accomplish electrical and mechanical services to nuclear propulsion plants. These range from simple valve repairs to testing and inspection of components. A few of the typical services performed are listed below:

- Minor valve repair
- Piping system repair or alteration
- Test and inspection of components and systems
- Steam generator cleaning

Numerous activities supported this work such as nuclear engineering and planning, supply, radiological controls, quality assurance, machine shops, and administrative groups required to plan and execute tasks as complex as maintaining a nuclear-powered warship.

3.3 **Site Description**

3.3.1 **Site Land Use**

The physical features of HPA are discussed above and shown in Figure 3.4. The majority of the land area within the boundaries of the shipyard site is covered by structures or is paved with concrete and asphalt.

During operation of HPA, 24,000 linear feet of pier, quay wall, and wharf space provided forty 500-foot berths. These included 21 fully-equipped repair berths along with 19 deep water berths which were not fully equipped for repair. Six drydocks (Nos. 2, 3, 4, 5, 6, and 7) were in use, ranging from 420 feet to 1092 feet in length, and 27 feet to 47 feet in depth.

Temporary and permanent facilities were designed to meet different historical mission requirements. Many structures built during World War II were erected as temporary facilities, while buildings built after the war, such as the facilities of the Naval Radiological Defense Laboratory (NRDL), were designed as permanent facilities. After NRDL operations ended in 1969, 397 buildings were used for industrial purposes and 57 buildings were used for housing and other non-industrial activities.

All Naval Nuclear Propulsion Program (NNPP) radiological work was performed in Drydock 4 and on ships serviced in Drydock 4. This drydock was surveyed and released from radiological controls after each use by Mare Island Naval Shipyard (MINS; the radiologically-qualified facility performing the maintenance). Buildings 300, 367, and 439, located near Drydock 4, were used to support NNPP personnel, but were not used for radiological work or storage. The drydock and supporting work facilities were within the controlled industrial area. Building 439, which was used primarily for office space and storage of non-NNPP materials, was outside of the controlled industrial area.

Since all work performed on reactor plants was done aboard the ships, Drydock 4 was the only shipyard facility dedicated to radiological work. Work which required services not available in-hull was taken to MINS. No buildings at the shipyard were used as radioactive material work or storage areas.

Radioactive material shipments traversed the non-industrial area but were stored within the ships (or temporarily within or near Drydock 4). Open paved areas outside the controlled industrial area were used for storage of non-radioactive materials only, along with large equipment associated with ship repair functions. Consequently, areas other than Drydock 4 and immediately-adjacent open areas are not considered a potential source of NNPP radioactivity entering the environment.

3.3.2 **Demography and Adjacent Land Use**

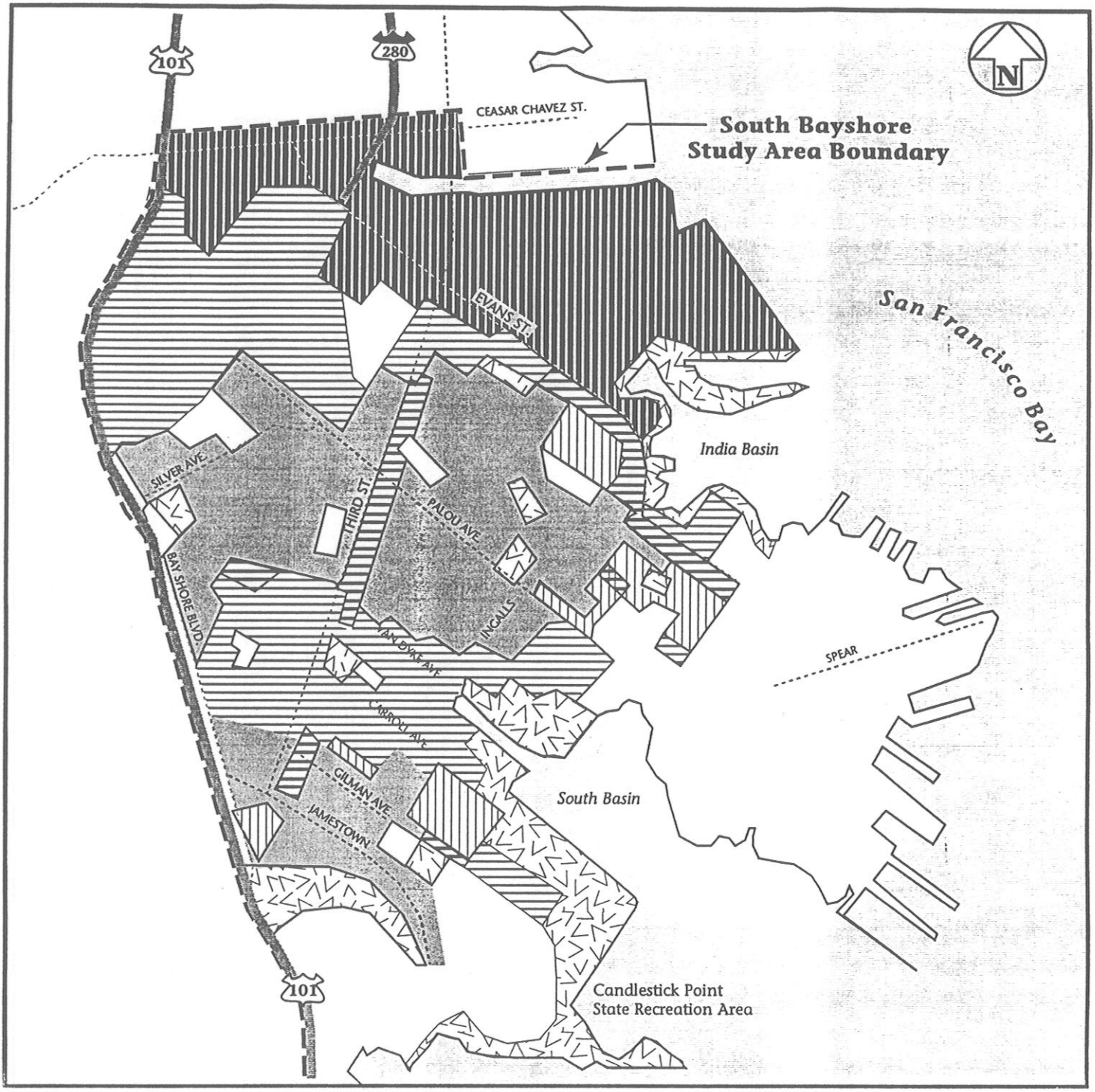
HPA is situated in a section of San Francisco that is not typical of the city in general. This region is loosely broken up into residential, industrial, and commercial recreation areas scattered around Mt. St. Joseph, Hunters Point Ridge, and Bevy Hill. The Bayview/Hunters Point housing project is situated north to northwest of HPA. This large area of housing is immediately adjacent to the HPA entrance gate. Nearby industries include auto wrecker and repair shops, food manufacturers, and a variety of other industrial activities. Other commercial ventures, such as stores and eating establishments, are also nearby. Figure 3.5 illustrates the use of land around HPA.

At the time of the 1990 census, over 4 million persons resided within the 50-mile radius from HPA. The metropolitan areas of San Francisco, Alameda, and Santa Clara counties contain most of this population. Table 3-1 shows the population for principal centers near HPA, all of which are within 10 miles. Table 3-2 shows the population of the counties within or partially within 50 miles of HPA.

3.3.3 **Physical Characteristics**

This section describes the geology, seismology, and geohydrology of the region around Hunters Point as they relate to infiltration of contaminants into ground waters, mobility and transport via the ground water, and confining features that preclude area-wide distribution of introduced potential contaminants.

The transport and distribution of materials in the local ground water is, in part, a function of the local and regional geological morphology and stratigraphy. Extensive studies have been conducted into the geology and hydrology of the Hunters Point area. References 1, 2, and 5 were used for information presented in this section.



- Heavy Industrial
- Light industrial
- Low Density Residential (14 to 29 units/acre)
- Medium Density Residential (30 to 54 units/acre)
- Mixed Use, Neighborhood Commercial
- Parks and Open Space
- Public Facilities

Figure 3.5
Land Use Surrounding
Hunters Point Annex

Table 3-1
Population and Population Density of
Cities within 10 Miles of Hunters Point Annex

City	Population Density (Persons per Square Mile)	Total Population
San Francisco	15,502	732,959
Oakland	6,635	372,242
Daly City	12,308	92,311
Alameda City	7,146	76,459
South San Francisco	6,035	54,312
San Bruno	6,088	38,961
Pacifica	2,990	37,670
Burlingame	6,233	26,801
Millbrae	6,379	20,412
Piedmont	6,236	10,602

Table 3-2: Population of Counties within
50-Mile Radius of Hunters Point Annex

County	Population
Santa Clara County	1,497,577
Alameda County	1,279,182
Sacramento County	1,041,219
Contra Costa County	803,732
San Francisco County	723,959
San Mateo County	649,623
San Joaquin County	480,628
Sonoma County	388,222
Solano County	340,421
Marin County	230,096
Santa Cruz County	229,734
Napa County	110,765

Note: Only portions of Sonoma, Napa, Solano, Sacramento, San Joaquin, Santa Clara, and Santa Cruz counties are within the 50-mile radius of Hunters Point Annex.

3.3.3.1 **Geology**

Hunters Point is located in the San Francisco Bay Area, which is in the central Coast Ranges of California. This area consists of a number of nearly parallel ranges averaging about 50 miles in width. The ranges end abruptly along the west coast of California, and terminate more gently along the edge of the alluvial plain of the Great Valley in the east. The region was occupied by a sea during Jurassic and Cretaceous times, as indicated by widespread deposits of marine sediments in the Coastal Ranges. These sediments are generally believed to have been derived from a land mass to the west which is now submerged.

Volcanic products and associated intrusives were formed during most epochs of the Tertiary period. The volcanic deposits are typically interbedded with lake and stream deposits and mud flows. These deposits are therefore considered very heterogeneous.

San Francisco Bay is a shallow body of water in a valley which was inundated by slowly rising seas that received melt water from the vast continental glaciers of the Quaternary period. The deepest sections of the bay are along old river channels. The basin of San Francisco Bay is an irregular down-warp which has been complicated by faulting and modified by erosion.

The Quaternary history of the area has been primarily governed by sea level fluctuations caused by glacial and interglacial stages, and by differential uplift. Both of these processes are likely still active. Sea level fluctuations greatly influence the erosional, depositional regimen of streams and rivers. Such fluctuations are recorded in the stratigraphy underlying San Francisco Bay. Deposition in the bay has been occurring since the mid-Pleistocene, and sediments indicate alternate deposition of terrestrial and marine sediments. Stages of low sea level are indicated by the presence of stream channels which were backfilled during the succeeding gradual rise of sea level.

The Hunters Point area is underlain by rocks which range in age from Jurassic-Cretaceous to recent. This formation, the Franciscan Group, is one of the most extensive assemblages of rocks in the Coast Ranges. It occupies approximately one-fifth of the total area of California but does not outcrop east of the Coast Ranges. At Hunters Point, the Franciscan Formation is bedrock and forms most of the original point. It underlies the basin sediments and consists of sandstone and shale, chert, greenstone (altered volcanic rock), and serpentine. The formation typically has widely varying physical properties and often exhibits a chaotic structure due to its complexity. Serpentine, from molten igneous rock which has been injected or intruded into sedimentary rock, forms major portions of the hills or high lands at the site.

The actual structure of the Franciscan Formation is poorly known due to its structural complexities and the lack of detailed exposures. The formation does not have distinctive marker beds or fossil assemblages, bedding is poorly developed, and much lateral variation in texture, thickness, and lithology is prevalent. Repeated crustal movements have resulted in a large amount of shearing or shattering. Almost every exposure has one or more sets of slickensided slip planes and gouge zones. A major shear zone extends northwest from Hunters Point to Fort Point in the Presidio Military Reservation. This zone is known as the Fort Point-Potrero Hill Hunters Point Shear Zone.

Unconsolidated deposits of sand, gravel, and clays overlie the Franciscan Formation near the site of HPA, and artificial fill overlies bay mud beneath the site. Much of the site was reclaimed from the bay by filling with soil and rock. Consolidation of the mud has resulted in a substantial settling of the reclaimed portions of the site.

The original cliffs at HPA were 280 feet above sea level. The cliffs were razed and used to fill lowland areas for buildings, roads, and shipyard operations. Approximately 400 acres of the dry land portion of HPA were filled on a level plane about 12 to 15 feet above sea level. The remaining HPA land is on an uplifted, moderately steep to steep formation of serpentine rock, with maximum elevation of approximately 130 feet above sea level.

Figure 3.6 shows a geologic cross section illustrating the stratigraphy beneath HPA. The simplified regional geology is shown in Figure 3.7.

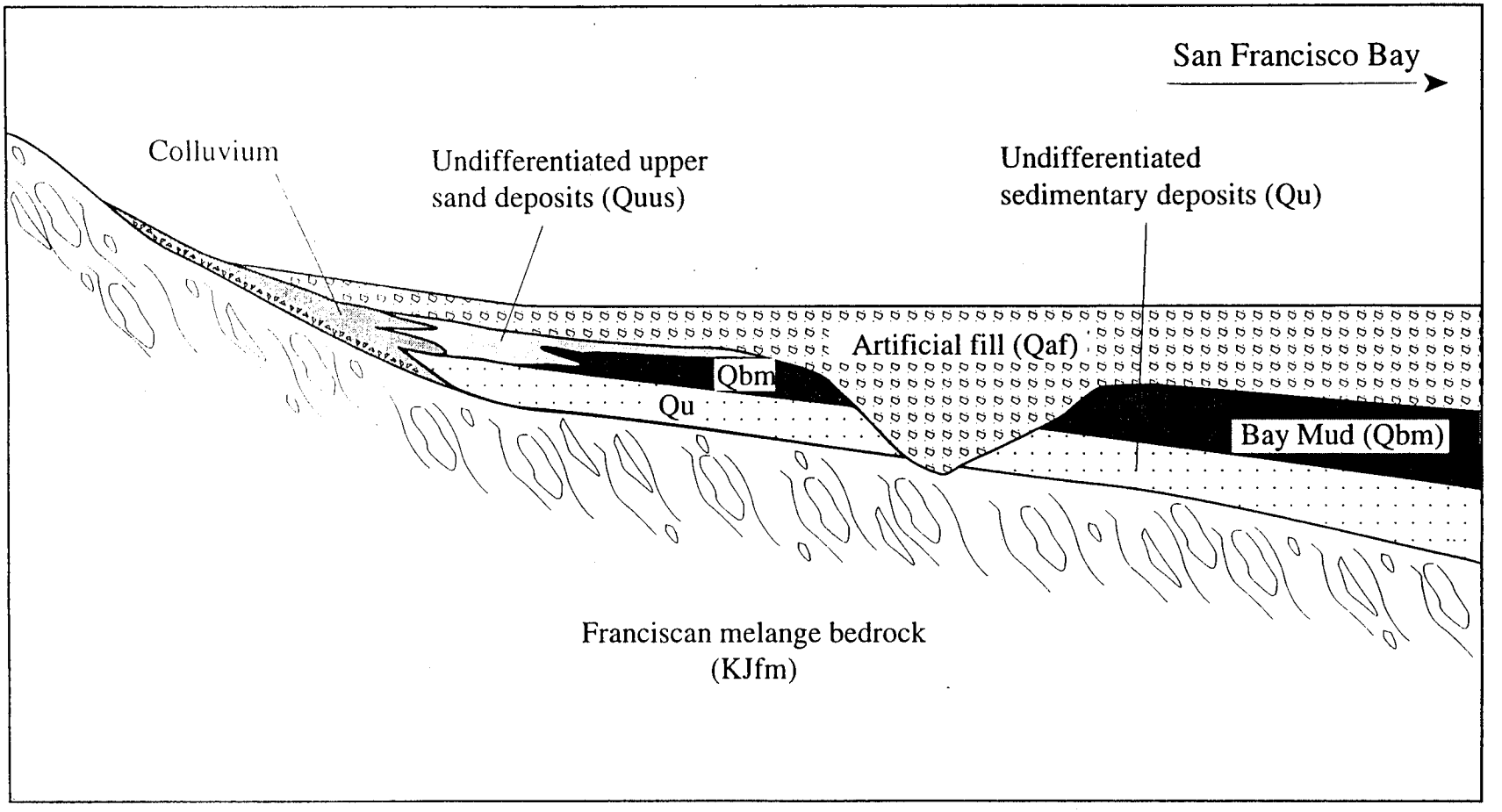
3.3.3.2 **Ground Water Sources and Uses**

Reference 5 presents a detailed discussion of the hydrogeology at HPA.

San Francisco contains seven ground water basins, including two oceanside and five Bayside basins. Two of the Bayside basins are significant since they equally divide HPA into the Islais Valley Groundwater Basin to the northeast and the South Groundwater Basin to the southwest. Figure 3-8 illustrates the locations of the San Francisco ground water basins.

Potable water for HPA is supplied by the City and County of San Francisco. Ground water in the vicinity of HPA is not used for domestic drinking water purposes, and is not likely to be used for such purposes since it is not near the more potentially productive valley bottom of the Islais Valley Groundwater Basin.

Figure 3.6
Geologic Cross-Section
of Hunters Point Annex



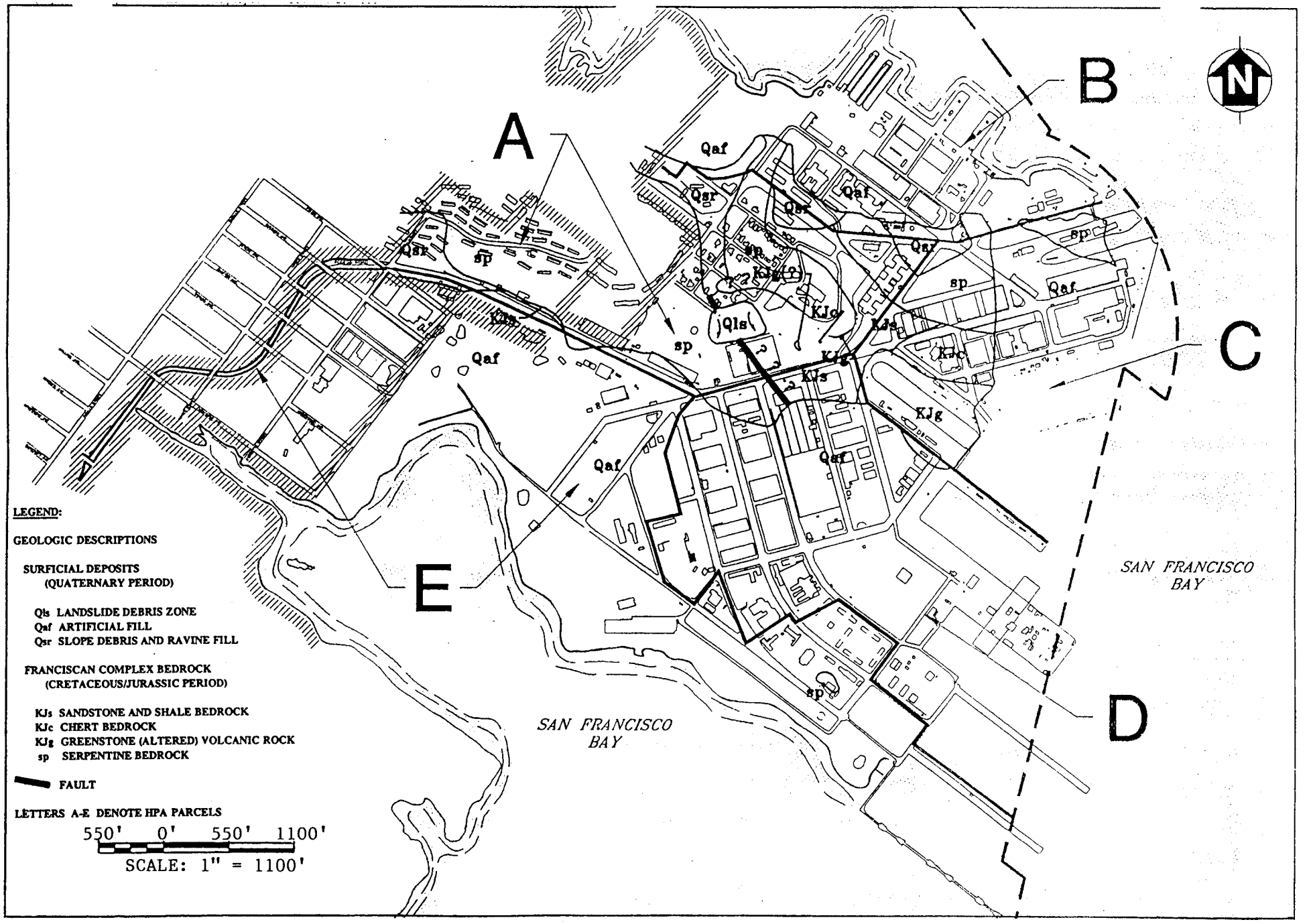


Figure 3.7
Simplified Regional Geology

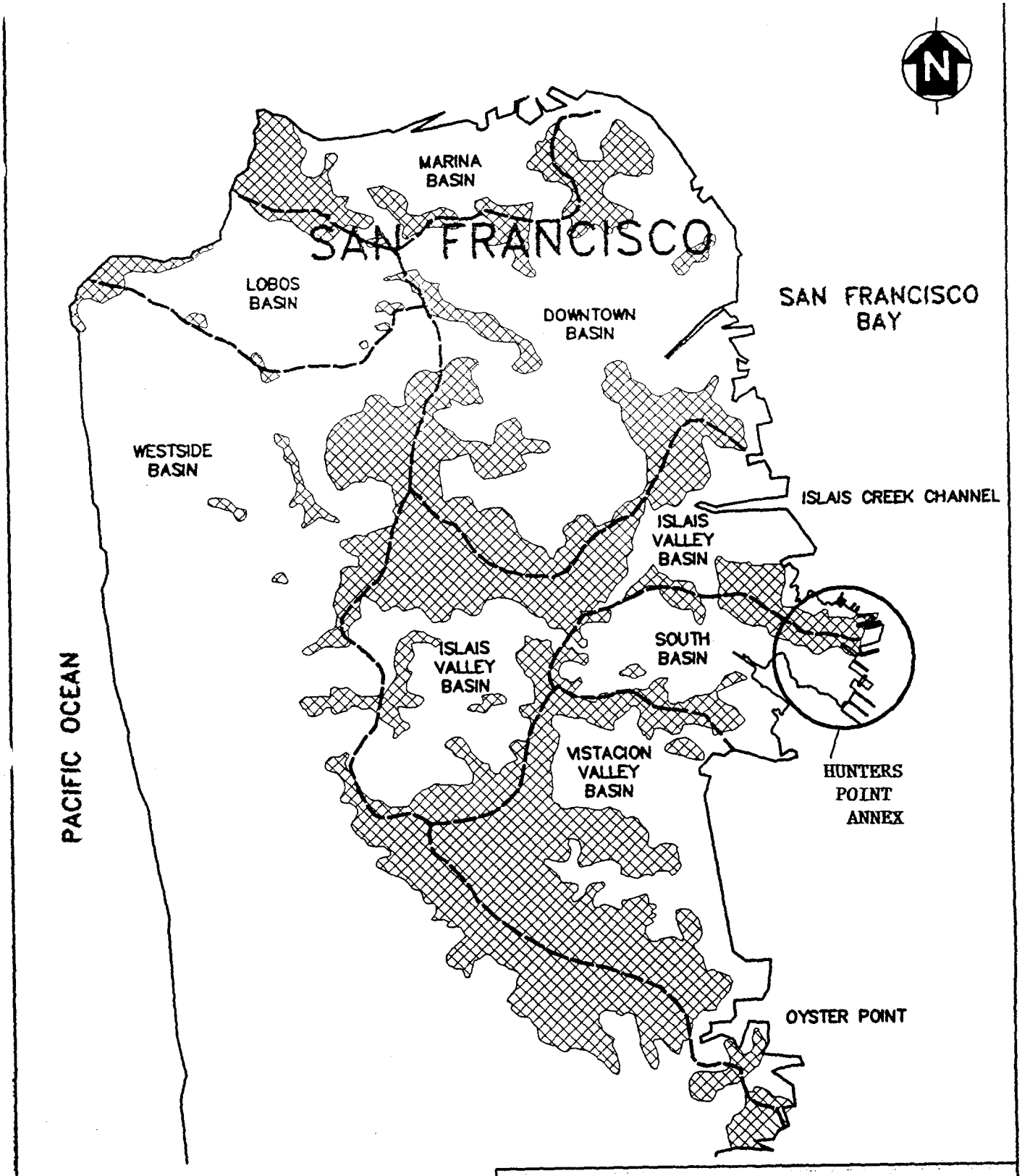


Figure 3.8
Groundwater Basins
Near Hunters Point Annex

Reference 2 reports a total of 34 wells within two miles of the geographic center of HPA, and 91 within 3 miles. The uses of seven of the 34 wells are known. Three were reportedly installed for irrigation, two for monitoring purposes (cathodic protection), and two for industrial use. Of the seven wells, one irrigation well is active and one other well is inactive. The status of the five other wells is unknown. Irrigation wells are reportedly used by area well owners. Reference 1 reports: no operational wells are within one mile of HPA; one operational well is located at Williams Street, within two miles of the site; and three operational wells are located at Alabama, Raymond, and Neahall Streets, within three miles of the site. All wells at HPA are monitoring wells.

A spring at Evans Avenue, within one mile of HPA, is being used for commercially bottled water. The spring emanates from fractures in the Franciscan Formation at elevations greater than 200 feet. The spring water is from the California Sierra aquifer, having traveled deep beneath San Francisco Bay. Since most industrial operations at HPA occurred at elevations below 120 feet, any potential contamination would not be expected to affect the spring.

Ground Water Flow in the Vicinity of HPA

Two aquifers and one water-bearing zone are identified at HPA: the A-aquifer, the B-aquifer, and the bedrock-bearing zone.

The A-aquifer consists of saturated, porous media such as artificial fill and undifferentiated upper sand deposits overlying Bay Mud Deposits. The A-aquifer may overlie bedrock directly in excavated areas at the former (1935) shoreline. The A-aquifer is unconfined, with depths to ground water ranging from 2 to 17 feet below ground surface. The aquifer is recharged by precipitation infiltration in the unpaved area, Bay water intrusion, and possible water leakage from storm drains and sanitary sewer systems. Ground water in the A-aquifer generally flows outward toward San Francisco Bay, except where it is reversed due to the possible influence of a pumping station and tidal influences along the shoreline.

The A-aquifer and underlying B-aquifer are separated by Bay Mud Deposits. Clay and silt, which make up the greatest portion of the Bay Mud Deposits, act as an aquitard or vertical hydraulic barrier (confining) layer between the A-aquifer and B-aquifer.

The B-aquifer consists of saturated, porous Undifferentiated Sedimentary Deposits underlying Bay Mud Deposits and overlying the Franciscan Complex Bedrock in the lower elevations of HPA. The B-aquifer is generally a confined, porous media aquifer where the ground water is under pressure. In some areas Bay Mud Deposits are absent between the A-aquifer and B-aquifer, so the B-aquifer is unconfined or semiconfined at these locations. Recharge of the B-aquifer is generally unknown, but the bedrock water-bearing zone and San Francisco Bay are likely to contribute to it. In general, the ground water in the B-aquifer at HPA flows outward toward San Francisco Bay.

The bedrock water-bearing zone is at the upper, weathered portions of the deeper, fractured portions of the Franciscan Complex Bedrock. Ground water in the bedrock is limited to discrete fractures of shear zones or weathered portions. The bedrock water-bearing zone is likely to be recharged from precipitation, runoff, possible leakage from storm drains and sanitary sewers, and the A-aquifer. The direction of ground water flow in the bedrock water-bearing zone at HPA is not fully understood because of the uncertainty associated with its continuity.

Areas at lower elevations at HPA are within a regional ground water discharge area. Ground water at HPA, from fractured bedrock aquifers, unconsolidated formations, and fill, is shallow. Located just below land surface to a depth of ten feet, ground water within the site will eventually discharge into San Francisco Bay.

The highlands comprise a regional recharge area, receiving recharge where flow is predominantly downward. The flow eventually becomes horizontal and predominantly upward as it discharges into the regional discharge area.

Between the regional recharge and discharge areas, many local flow systems may exist, upon the larger, regional system. These flow systems are controlled by seasonal changes in infiltration, evapotranspiration, and tidal stages in the bay. On a local scale, many recharge areas may exist. However, local recharge cannot migrate great distances through the ground water system. Tidal influence studies indicate that tidal fluctuations in San Francisco Bay impact ground water levels in monitoring wells installed within approximately 300 to 500 feet of the shoreline at HPA.

Ground Water Quality

The regional quality of the Islais Valley and South Groundwater Basins is unknown, although toxic chemical sites east of Highway 101 have been identified. The few wells that have been developed in these basins are known to produce water quality ranging from drinking water quality to water that exceeds primary drinking water standards for nitrate and secondary drinking water standards for dissolved solids. Well water samples from the ground water basins are high or very high in calcium carbonate.

3.3.3.3 **Surface Water Sources and Uses**

HPA is bordered by San Francisco Bay and two freshwater streams, Yosemite and Islais Creeks, that flow into the Bay adjacent to the site. Surface water resources at HPA are limited to small ground water seeps from exposed bedrock and the surface water in the adjacent San Francisco Bay.

Fishing, boating, and wind surfing are the primary recreational activities that take place in San Francisco Bay. As many as 200 boats can be anchored 50 to 200 yards from the HPA shore at one time. Swimming is infrequent.

Extensive fishing occurs in an area between two miles north and two miles south of HPA. The area surrounding Hunters Point provides one of the few recreational angling opportunities in the industrialized and developed South San Francisco shoreline, where public access for fishing is extremely limited. As many as 150 people were once observed shore fishing near HPA at one time. Fishing is done from public piers, from shore, and aboard sport boats. Recreational angling has been observed throughout the year with apparently no seasonal pattern, and subsistence fishing also takes place.

Many commercial fisheries that were once important to the Bay Area economy have disappeared, and although other commercial fisheries have been revived in recent years, there has been an overall change in emphasis from commercial to recreational fishing. This has been largely due to legislation restricting the commercial harvest of anadromous species such as salmon, striped bass, and sturgeon.

Harbor Dynamics

The bay system, including San Pablo and Suisun Bays, covers an area of 400 square miles. The system is formed by the discharge of the Sacramento and San Joaquin Rivers, which contribute 680 billion cubic feet of the total annual 750 billion cubic feet of inflow to the bay. Other sources of inflow include the Petaluma and Napa Rivers in the North Bay, Alameda and San Lorenzo Creeks from the East Bay, Coyote Creek and the Guadalupe River from the South Bay, and Redwood Creek and San Francisquito Creek from the peninsula.

The tidal range at the nearby Golden Gate Bridge varies from a high of 7 feet above mean sea level to a low of 1.1 feet below mean sea level. Generally, prolonged onshore winds or a low barometric pressure can produce a higher level than predicted. Strong winds and freshets, however, bring about nontidal currents which may modify the speed and direction of the currents considerably. Bay currents near Hunters Point are moderate. Peak surface tidal currents adjacent to Hunters Point average 1.7 knots on both flood and ebb tides.

Surface Run-off

Average annual rainfall at HPA is 19.71 inches, with 70 percent of the rainfall occurring from December to March. All surface water run-off that is not collected by the storm water sewer system drains toward San Francisco Bay, which surrounds HPA.

Water Quality

Water quality problems exist in San Francisco Bay. Most heavy-metal concentrations have been reduced to normal levels in the last 20 years. However, point sources such as bayshore landfills and industrial discharge outlets continue to introduce contaminants, including heavy metals, into the bay. Nonpoint sources, such as surface runoff, contribute soil from land erosion or construction projects, oil and grease from surface streets, and pesticides.

Surface water in the vicinity of Hunters Point is not used for domestic drinking water purposes. Potable water for HPA is supplied by the City and County of San Francisco.

Coastal uses near and on the bay are regulated by the Bay Conservation and Development Commission. Discharges from point and nonpoint systems to the bay waters are regulated by the California Regional Water Quality Control Board, San Francisco Bay Region.

Much of the bay's margins have been subject to diking and filling. Wetlands, which include tidal marshes, salt flats, and seasonal floodplains, are only abundant in the Upper Bay and South Bay regions. Many of the wetland areas in the South Bay are seasonally flooded and converted into salt flats. HPA is centrally located in the bay; however, seven habitat types, including wetland areas, along with two mudflats, exist on the site, as discussed in Section 8.2.2.

Man-induced changes in the environment are implicated in the decline of certain fishery resources. Water storage and diversion projects have affected the distribution and abundance of salmon and striped bass, and land reclamation and domestic sewage pollution essentially eliminated the clam and oyster industries. Although considerable progress has been made in improving water quality in the bay in recent years, shoreline waters are apparently not yet free enough of sewage contamination for the State Public Health Department to sanction harvesting of bay shellfish for consumption.

3.3.3.4 **Seismology**

Seismic risk maps published by the U.S Coast and Geodetic Survey place the coast of California in risk zone 3, indicating an expectancy of major damage due to earthquakes (see Figure 3.9). Major faults underlie the Bay Area, and the region is considered seismic as shown on Figure 3.10.

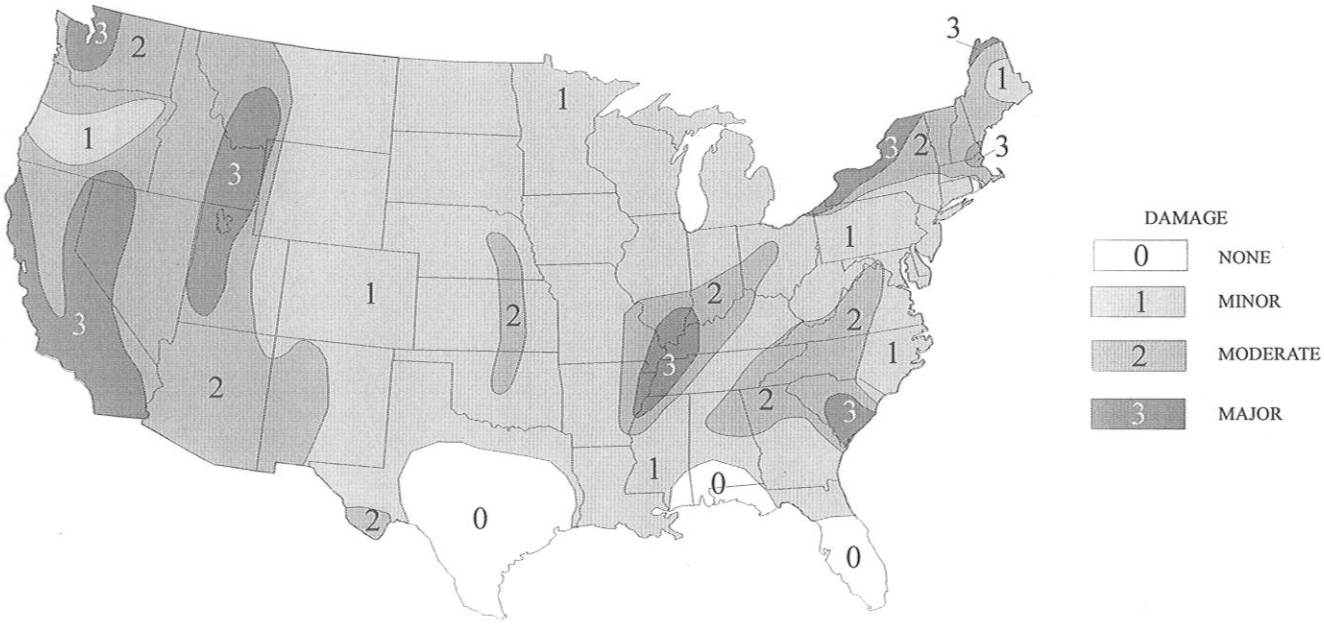


Figure 3.9 Seismic Risk Map for Conterminous U.S.

The map divides the U.S. into four zones: Zone 0, areas with no reasonable expectancy of earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, where major destructive earthquakes may occur.

Reference: Robert J. Foster, "Physical Geology," Charles E. Merrill Publishing Company, Second Edition, 1975

The San Francisco Bay region is one of the most seismically active regions of the United States. Major fault zones pass through the Bay Area in a northwest direction. This fault system includes the San Andreas, Hayward, and Calaveras faults, located 7 miles southwest, 10 miles northeast, and 20 miles east of HPA, respectively. Several other faults of lesser or unknown seismic activity also trend in the northwest direction in the general vicinity of HPA. These include the San Bruno, Hillside, and City College Faults, located 5, 4, and 1.7 miles, respectively, southwest of the site. HPA is within a zone which would experience violent ground shaking during a large earthquake on the San Andreas or Hayward faults.

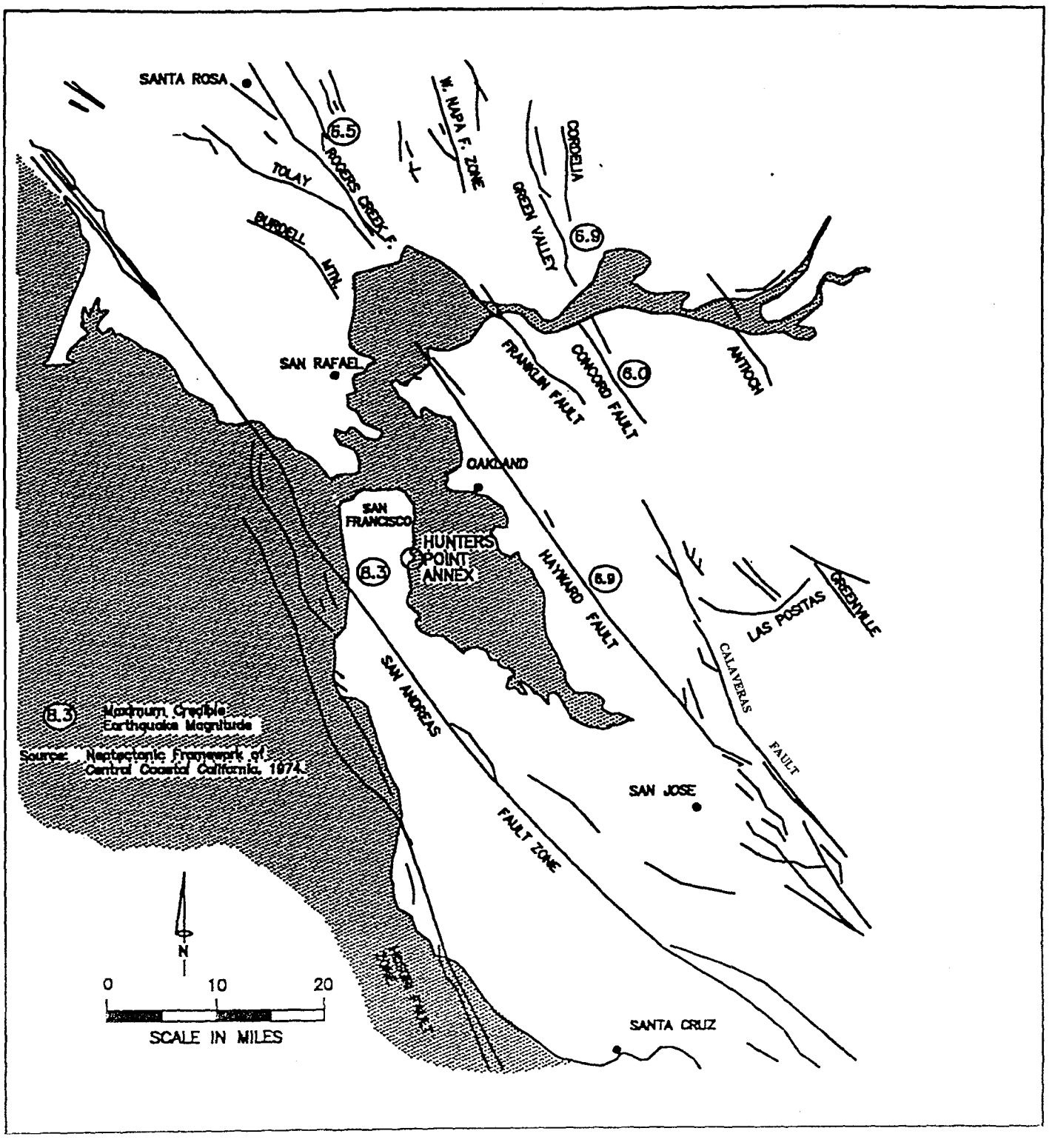


Figure 3.10
Regional Faults
in the
San Francisco Bay Area

Most of the seismic activity is generated along the San Andreas and Hayward Faults. The San Andreas Fault is the system on which the most recent major seismic event affecting the area occurred: the October 17, 1989 Loma Prieta earthquake. The San Andreas Fault is expected to produce maximum credible and maximum probable seismic events of 8.5 and 8.0 magnitude on the Richter scale, respectively.

The Hayward Fault, located approximately 11 miles northeast of HPA, parallels the San Andreas Fault, along the base of the Coast Mountain foothills in the East Bay. The Hayward Fault has maximum credible and maximum probable earthquake events estimated to be 7.5 and 7.0 magnitude on the Richter scale, respectively. The last major earthquake along the Hayward Fault occurred in 1868.

Although no active faults are known to underlie HPA, there is evidence of ancient shearing and faulting in the Franciscan bedrock in the center portion of HPA. An inactive shear zone extends from the southeast at HPA to the northwest toward the Golden Gate National Recreation Area.

Destructive earthquakes have occurred in the San Francisco Bay Area in 1836, 1838, 1861, 1865, 1868, 1906, and 1989. Other less severe but damaging earthquakes have also occurred in the area.

Ground failure resulting from earthquake-induced soil liquefaction is an important risk threat during earthquakes since saturated granular materials in liquefaction-prone soils can be transformed by seismic shaking into a fluid-like state, causing ground failure and consequent structural damage to buildings and infrastructure. Although isolated areas of HPA may be susceptible to liquefaction, large areas of the site are underlain by heterogeneous unsaturated fill which is unlikely to liquify. However, it is possible that severe ground movement could result in settlement of fill at HPA, with detrimental effects on buried utilities and waterfront areas, as shown during the Loma Prieta earthquake.

The weathered rocks and serpentine that compose the higher slopes in the central portion of Hunters Point are subject to landslides which could result from earthquakes. Small landslides might also occur on steep slopes underlain by thick soil.

Tsunamis are long-period waves usually caused by underwater seismic disturbances, volcanic eruptions, or submerged landslides. Because of the low elevation of much of HPA and its proximity to the bay, HPA is considered susceptible to inundation by tsunamis. The site could be inundated by tsunamis passing through the Golden Gate. Estimated tsunami runup heights for the probable 100-year tsunami ranges from elevation 3.9 to 5.7 feet above mean sea level around HPA. The 500-year tsunami runup ranges from 5.0 to 9.7 feet above mean sea level. Inundation of this type could be expected to produce severe damage, with more severe damage occurring at northern portions of the site.

Seiches are waves in an enclosed body of water caused by seismic shaking, climatic forces, or landslides into the water body. Large seiches also can result in flooding. Although seiches are possible in San Francisco Bay, the largest ever measured in the bay was four inches following the 1906 earthquake. Seiches of such magnitude would not pose a hazard to the site.

3.3.4 **Climatology**

The prevailing winds of the San Francisco Bay Area are from a westerly direction and range from 6 to 11 knots. Records show that winds of gale force or greater have occurred only rarely in the area. Heavy fogs occur on the average of 21 days per year. These fogs impair visibility for navigation at Oakland an average of less than 100 hours per year. Freezing temperatures rarely occur, and no snow or icing conditions are encountered. Rainfall averages approximately 20 inches annually, generally occurring from October to May.

In California, the Pacific Ocean and rugged topography exert the most important controls upon the climate. Isotherms run mostly north-south instead of the more common east-west trend, following elevation contours and the Pacific Coast rather than the parallels of the latitude. The semi-permanent high and low pressure areas of the North Pacific Ocean are fundamental to the types of climates which occur in the Pacific Coast region. These pressure centers bring about the prevailing westerly to northwesterly winds on the coast. Under these wind flows most of the year, the Pacific Coast is characterized by relatively warm winters, cool summers, small daily and seasonal temperature ranges, and moderate relative humidities. Cold waters off the Northern California coast, combined with the comparatively warm moist Pacific air, result in the formation of fog, which is swept inland along the entire Pacific Coast by the prevailing winds. Fog may be expected as early as November, is usually encountered until March, and is most frequent and heaviest in January and February.

HPA does not lie within the 100-year flood plain, as defined by the U.S. Geological Survey. Figure 3.11 shows the areas of potential flooding in the event of a tsunami.

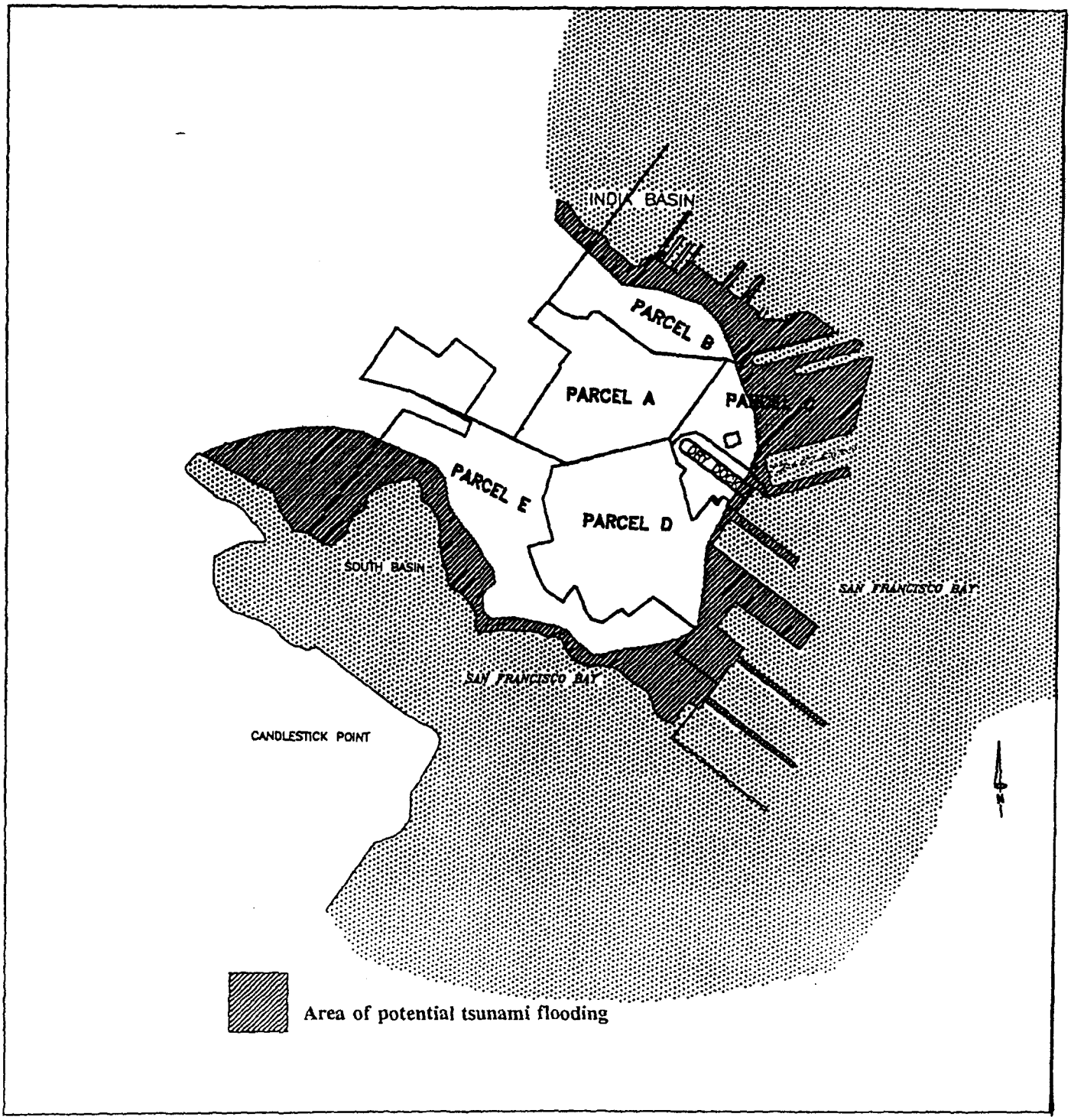


Figure 3.11
Flood Zone Map for Hunters Point Annex

4.0 DESCRIPTION OF OPERATIONS

4.1 Background on Navy Organizational Activities

4.1.1 Naval Facilities Engineering Command (NAVFAC)

NAVFAC is responsible for taking the lead in negotiating Federal Facility Agreements (FFAs) with EPA regional offices and states.

4.1.2 Naval Nuclear Propulsion Program

The Naval Nuclear Propulsion Program is a joint Department of Energy (DOE)/Department of the Navy program comprised of military and civilian personnel who design, build, operate, maintain, and oversee operation of Naval nuclear-powered ships and associated support facilities. The Program has a broad reach, maintaining responsibility for all aspects of Naval nuclear propulsion plants (including control of radiation and radioactivity) from cradle to grave. It is completely separate from the rest of the Navy and DOE activities that deal with radioactivity. Program responsibilities are delineated in Presidential Executive Order 12344 of February 1, 1982, and enacted as permanent law by Public Law 98-525 of October 19, 1984 (42 U.S.C. 7158). Program elements include:

- The Navy's nuclear-powered warships;
- Research and development laboratories;
- Contractors responsible for the design, procurement, and construction of propulsion plant equipment;
- Shipyards that construct, overhaul, and service the propulsion plants of nuclear-powered vessels;
- Navy nuclear support facilities and tenders;
- Nuclear power schools and Naval Reactors training facilities; and
- The Naval Nuclear Propulsion Program headquarters organization and field offices.

Admiral H.G. Rickover developed the Naval Nuclear Propulsion Program at the end of World War II, with a commitment to technical excellence and an organization staffed by experienced professionals dedicated to designing, building, and operating Naval nuclear propulsion plants safely and in a manner that protects people and the environment. Executive Order 12344 and Public Law 98-525 capture the concepts and principles central to the Program's accomplishments.

Dealing with radioactive materials and ionizing radiation safely and responsibly has been an integral part of the NNPP from the beginning. It was recognized that the usefulness of nuclear-powered warships would be seriously hampered if operational restrictions were necessary because of radiological concerns. Therefore, the reactor plants were designed and continue to be operated such that the radiological impact on people and the environment is minimized. The NNPP established limits for releases to the environment which were well below limits applied to operation of commercial nuclear power plants. NNPP policy has been to control radioactivity such that radiological environmental impact is insignificant compared to natural radioactivity levels in the environment. From the start of the Naval Nuclear Propulsion Program, the policy has been to reduce to the minimum practicable the amounts of radioactivity released into the environment.

4.2 **Radioactivity from Naval Nuclear Propulsion Plants**

Naval nuclear propulsion plants differ from commercial power generating reactors in several important ways with respect to potential environmental impact. They are considerably smaller both in physical size and power output. To assure safe operation in close proximity to operating crews under possible high shock loading of battle conditions, the reactor plants are much more durable. Leakage of fission products into the cooling system, or leakage of the cooling system, are not compatible with ship operation and are not tolerated. Over 40 years experience with Naval nuclear propulsion plants has shown that fission products are contained in the fuel elements. This characteristic significantly reduces the potential for radiological environmental impact.

In the shipboard reactors, pressurized (non-boiling) water circulating through the reactor core picks up the heat of nuclear reaction. The reactor cooling water circulates through a closed piping system to heat exchangers which transfer the heat to water in a secondary steam system isolated from the primary cooling water. The secondary system water is turned into steam, which is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Releases from the shipboard reactors occur primarily when reactor cooling water expands as a result of being heated up to operating temperature; this coolant passes through a purification system ion exchange resin bed prior to being transferred from the ship.

While fission products produced in the fuel, including iodine and the fission gases krypton and xenon, are retained within the fuel elements, some trace quantities of naturally occurring uranium impurities in the surface of reactor structural materials release small amounts of fission products to the reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides comprises only a small fraction of the total long-lived gamma radioactivity releases discussed elsewhere in this section of this report.

The primary mechanism by which environmental releases of NNPP radioactivity occur include: (1) inadvertent releases of small volumes of liquids (or pre-1972 historical releases) to the harbor, as discussed in Section 5.1.1; (2) inadvertent releases of small amounts of liquid or solid material (or, very rarely, gases), as listed in Section 5.1.3; (3) the particulate output from HEPA-filtered air exhausts at work areas, as discussed in Section 5.1.2; and (4) the release of trace quantities of fission product gases and carbon-14 gaseous products from primary coolant which has been depressurized (including that which is removed from ships for processing, as discussed in Section 5.1.1.1). Note that ships are prohibited from discharging reactor cooling water overboard in the vicinity of shore; hence, shipboard reactor operations are not considered a significant potential source of environmental contamination.

4.2.1 **Cobalt-60**

The principal source of radioactivity in liquid effluents or encountered during maintenance work is trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Radionuclides with half-lives of approximately one day or greater in these corrosion and wear products include tungsten-187, chromium-51, hafnium-181, iron-59, iron-55, nickel-63, niobium-95, zirconium-95, tantalum-182, manganese-54, cobalt-58, and cobalt-60. The most predominant of these is cobalt-60, which has a 5.3 year half-life. Cobalt-60 also has the most restrictive concentration limits, as listed in Reference 6. Therefore, cobalt-60 is the primary radionuclide of interest for Naval nuclear propulsion plants.

4.2.2 **Tritium**

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and as a result of certain other nuclear reactions. Although tritium has a 12.3 year half-life, the radiation produced is of such low energy (weak beta; no gamma) that the Reference 6 radioactivity concentration limit for tritium is at least one hundred times higher than for cobalt-60. This tritium is in the oxide form (i.e., water) and is chemically indistinguishable from normal water; therefore, it does not concentrate in marine life or collect on sediment as do other radionuclides.

Tritium is naturally present in the environment because it is generated by cosmic radiation in the upper atmosphere. Reference 7 estimates the natural production rate of tritium would produce a global equilibrium inventory of between 28 million and 70 million curies. Table 3.3 of Reference 7 shows that 65 percent of the global inventory occurs in oceanic waters. These values yield an oceanic inventory of about 18 million to 45 million curies. Because of this naturally occurring tritium, much larger releases of tritium than are conceivable from Naval nuclear reactors would be required to make a measurable change in the background tritium concentration.

The total amount of tritium released annually from all U.S. Naval nuclear-powered ships and their supporting tenders, bases, and shipyards has been less than 200 curies. Most of this has been into the ocean more than twelve miles from shore. The total tritium released annually from the entire nuclear Navy is less than single electrical generating nuclear power stations typically release each year. Total tritium released annually into harbors within twelve miles of shore is less than one curie. Appendix B of Reference 7 reports an estimated dose due to natural tritium in the environment of between 1.0 µrem/yr and 1.5 µrem/yr. In comparison to the millions of curies naturally occurring in the oceans, the 200 curies of tritium per year released from nuclear ships is insignificant to both the global inventory and to the annual dose due to the environmental tritium. Therefore, tritium has not been combined with the data on other radionuclides in other sections of this report.

4.2.3 **Carbon-14**

Carbon-14 is also formed in small quantities in reactor coolant systems as a result of neutron interactions with nitrogen and oxygen. This carbon is in the form of a gas, primarily methane and ethane, although some insoluble carbonates may be present; following reprocessing of reactor coolant, it is possible some carbon-14 has been converted to carbon dioxide. Carbon-14 decays with a half-life of 5,730 years; however, only low energy beta radiation is emitted as a result of this decay process. As a result, the Reference 6 radioactivity concentration limit for carbon-14 in its chemical form in air is sixty times higher than for cobalt-60.

Carbon-14 occurs naturally in the environment. It is generated from cosmic radiation interactions with nitrogen and oxygen in the upper atmosphere and oxidized to form carbon dioxide. Appendix B of Reference 7 states that "weapons testing has essentially doubled the atmospheric inventory of carbon-14 present from natural sources." Carbon-14 is chemically indistinguishable from other isotopes of carbon. The carbon dioxide diffuses and convects throughout the atmosphere and enters the earth's carbon cycle (i.e., achieving equilibrium concentrations in all living organisms; this is what permits "carbon dating" of deceased organisms, since carbon-14 in dead matter decays and is not replenished).

The earth's carbon-14 inventory is estimated to be about two hundred and fifty million curies. The total amount of carbon-14 released annually from the operation of all U.S. Naval nuclear-powered ships and their supporting tenders, bases, and shipyards has been less than 100 curies. Since the inventory of naturally occurring carbon-14 is millions of curies, releases from Naval nuclear reactors do not result in a measurable change in the background concentration of carbon-14.

Typical annual releases of carbon-14 at Naval facilities are about 1 curie per year, virtually all as a gas. This is much less than the approximately 7 curies per year discharged by the typical commercial nuclear power plant per Reference 8. These gaseous releases are dispersed in the atmosphere and are not concentrated in the environment. Calculations using the EPA COMPLY computer code indicate that the resulting dose is less than 1 mrem per year. Furthermore, studies around a large civilian nuclear power plant showed no measurable carbon-14 in downwind foliage (Reference 9). For these reasons, carbon-14 is not judged a remediation concern, and carbon-14 data has not been combined with the data on other radionuclides in other sections of this report.

4.3 **Type of Activities**

Navy facilities authorized to perform radioactive work associated with Naval nuclear propulsion plants perform a wide range of maintenance, repair, and upgrading activities. Some facilities also refuel reactor plants (not done at Hunters Point Annex). Refueling involves removal of spent fuel into special shipping containers and installation of new fuel. No work on or processing of fuel is performed at these facilities. Radioactive materials encountered during reactor plant work include reactor coolant that is processed and reused, reactor plant components (including removed and/or unusable components), tools and equipment used to perform the work, reusable (laundered) contamination control clothing, and contamination control waste products such as plastic bags, tape, plastic bottles, and impervious fabrics.

Trade skills required for reactor plant work are the same as for typical shipyard operations. Machinists, pipefitters, shipfitters, welders, sheet metal workers, electricians, painters, fabric workers, and riggers perform the work. Work is directed by engineers and monitored by inspectors and radiological control technicians. The primary differences from other work are the extremely high quality standards and the interaction with radiation and radioactive materials. For example, it is common to train personnel on uncontaminated mockups prior to performing work on contaminated systems, to minimize exposure and help preclude errors.

4.4 **Control of Radioactivity**

A major objective in the performance of Naval nuclear propulsion plant work is avoiding the potential for releases of low level radioactivity into the environment. From the beginning of the NNPP, radiological work has been performed under strict controls to preclude the spread of contamination, by containing radioactivity at the source to the smallest practicable area or volume. Facilities where work on radioactive materials is performed are specifically designed to contain radioactivity. Design criteria include impervious walls, easily decontaminated surfaces, absence of floor drains, and ventilation systems with High Efficiency Particulate Air (HEPA) filtered exhausts to maintain a negative pressure in work areas. The HEPA filters are 99.97% efficient at removing 0.3 micron particles. The filtered exhausts are monitored with an Environmental Monitoring System; results of this monitoring are discussed in Section 5.

In addition, most work on radioactive materials is performed inside contamination containment areas inside these facilities with all the same features as the building. This provides double isolation of radioactivity from the environment. In the event of a loss of containment (e.g., a liquid spill or a puncture in a containment), immediate action is taken to isolate and correct the problem, and to sample/survey to verify complete recovery.

Radioactive material in storage areas is packaged to contain any loose radioactive contamination and is surveyed prior to transfer by radiological control personnel to ensure the outside of the packaging is not contaminated. Radioactive material storage areas are surveyed for loose radioactive contamination periodically by radiological control personnel.

Radiological work areas within the ships being serviced are designated as radiologically controlled areas. These areas are physically separated from the rest of the ship. Access to the radiologically controlled area for both personnel and material is via a control point manned by radiological control personnel. Personnel and material exiting a radiologically controlled area are surveyed for radioactive contamination with beta-gamma friskers.

All areas within a radiologically controlled area are maintained less than 450 pCi/100 cm^2 (by swipe analysis), except for those areas designated and specially controlled as Controlled Surface Contamination Areas. Controlled Surface Contamination Areas are maintained at or near 450 pCi/100 cm^2 even during work on contaminated items. Radiologically controlled areas and Controlled Surface Contamination Areas are surveyed frequently by radiological control personnel to ensure that radioactive contamination levels are held below NNPP limits.

The NNPP controls radioactivity at the source by using the concept of total containment. This policy minimizes the spread of radioactive contamination to adjacent surfaces and to personnel. Engineered ventilation systems containing HEPA filters, drapes, glovebags, and tents are utilized to accomplish this goal. Any personnel, instructional, or equipment errors that result in even a minor spread of contamination halt the work until the cause is determined and corrective action is taken. This policy and its successful application allow most radiological work to be performed without personal protective clothing or respirators. In addition to permitting work to be accomplished more efficiently, the number and extent of radiological areas requiring release is minimized.

Radioactive materials are either maintained within controlled areas, or are attended or physically secured at all times. Movement of radioactive materials outside controlled areas requires a strict accountability system.

Routine radiological surveys in and around facilities where work on radioactive materials is performed confirm that controls are effective. Corrective actions are taken immediately in the unusual event that surveys identify unexpected radioactivity. Inadvertent releases are cleaned up immediately (within hours if practicable), and a critique is held to identify and correct the cause of the problem. Detectable radioactivity in uncontrolled areas is not permitted.

The basic policies covering control of radioactivity have not been changed since the beginning of the NNPP. There has been continuous upgrading based on over 40 years of experience. An example of this is development of processing methods to make radioactive liquids reusable as reactor coolant. Other examples of upgrading include improved work facilities, development of improved contamination containment area designs, solid radioactive waste volume reduction, improved radiological analysis of environmental samples, and the extensive use of engineered ventilation systems. Upgraded monitoring methods have not detected problems with the basic control methods which have been used from the beginning of the Program.

4.5 **Regulatory Oversight**

NNPP radiological controls at Hunters Point Annex (HPA) were overseen by Naval Nuclear Propulsion Program headquarters. Management of NNPP radiological controls was the responsibility of Mare Island Naval Shipyard (MINS). MINS work at HPA was overseen by NNPP headquarters, and was reviewed as part of the annual NNPP on-site audits of MINS. These reviews were performed in support of the NNPP authorization for the handling of NNPP radiological materials by MINS.

5.0 POLICIES AND RESULTS

5.1 Policies and Records Related to Environmental Release of Radioactivity

5.1.1 Liquid Discharges

5.1.1.1 Policy

General

As stated in Reference 10, the policy of the Naval Nuclear Propulsion Program (NNPP) is to minimize the amount of radioactivity released to the environment, particularly within twelve miles of shore (e.g., including into harbors). This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated into the Environmental Protection Agency in 1970), U.S. Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Sciences--National Research Council. To implement this policy of minimizing releases, the NNPP has issued standard instructions defining radioactive release limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities.

The policies and procedures instituted by about 1972 remain in place through the present. The total amount of long-lived (half-life greater than one day) gamma radioactivity released into harbors and seas within twelve miles of shore by the entire Naval Nuclear Propulsion Program has been less than 0.002 curie during each of the last twenty-six years. This total is for releases from U.S. Naval nuclear-powered ships and from the supporting shipyards, tenders, and submarine bases, including releases at operating bases and home ports in the U.S. and overseas and all other U.S. and foreign ports which were visited by Naval nuclear-powered ships. This activity level is conservatively reported as if it consisted entirely of cobalt-60, which is the predominant long-lived gamma radionuclide and also has the most stringent concentration limits.

Processing and Reuse of Radioactive Liquids

Radioactive liquids were not off-loaded or processed at Hunters Point Annex (HPA). Any radioactive liquids remained on-board where they would have been processed through an ion exchange filter and a metallic filter to remove most of the radioactivity (exclusive of tritium) prior to collection in a tank. Collected water was later transferred to another shore facility or a tender for further processing; Figure 5.1 shows a simplified block diagram of the liquid processing system which consists of particulate filters, activated carbon bed filters, mixed hydrogen hydroxyl resin, and colloid removal resin beds. This type of processing system has been developed and used successfully to produce water containing very low radioactivity levels. Even after processing to less than 10^{-6} μCi/ml (1000 pCi/l), reactor coolant was not discharged into the bay. Rather, it was returned to ships, or transferred to an authorized shore-based facility for further processing and purification.

Policy Details

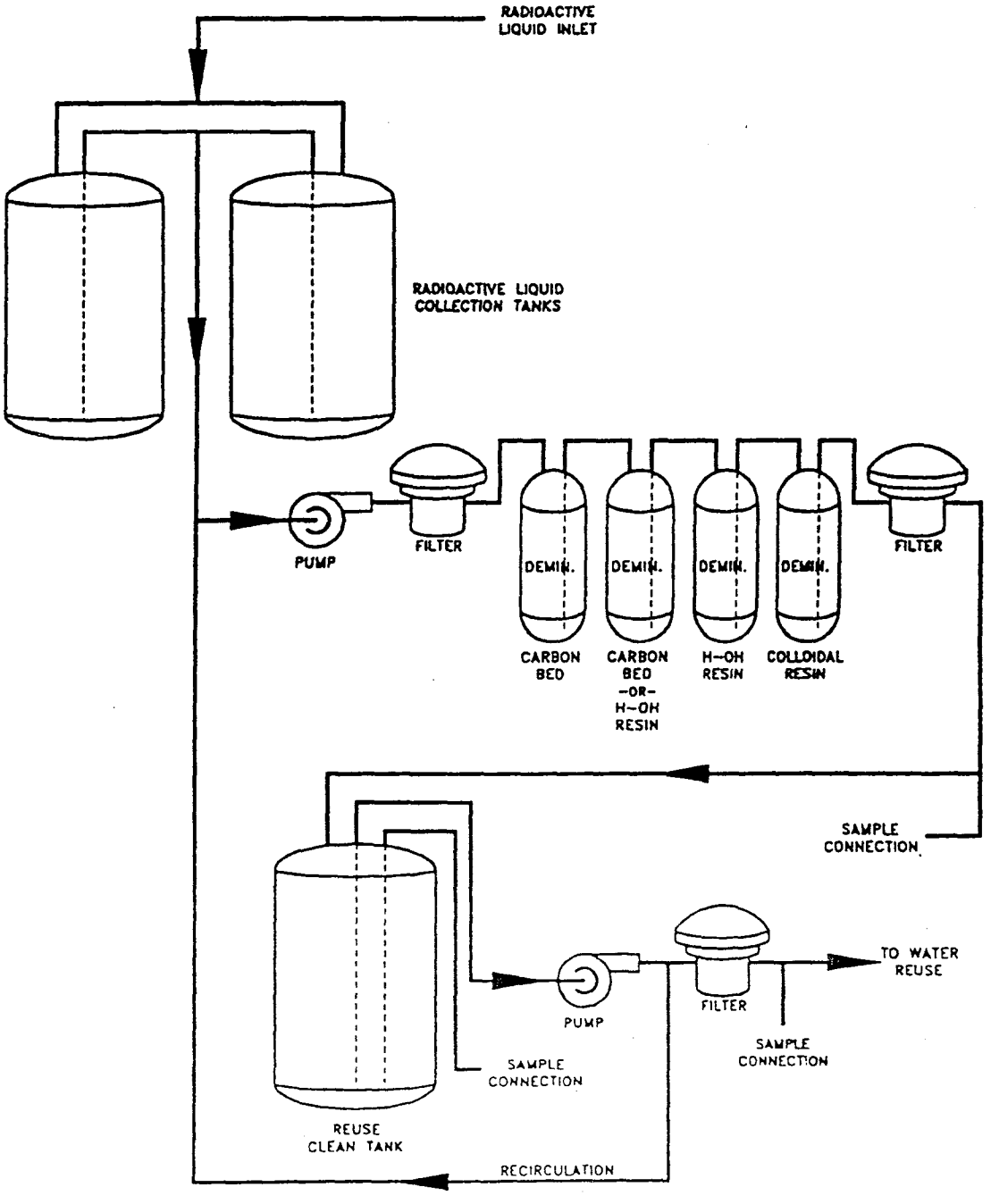
Standardized NNPP instructions concerning discharges of radioactive liquids from nuclear-powered ships were first issued in 1958. In 1960, all of the prior instructions were consolidated and incorporated into a technical manual for use by all Naval activities in their radiological control programs.

The basic criteria for release limits set in 1958 was that disposal of radioactive liquids should not increase the average concentrations of radionuclides in the surrounding environment by more than one-tenth of the maximum permissible concentrations for continuous exposure listed in National Bureau of Standards Handbook 52, Reference 11.

Measurements showed a dilution of over 100,000 for reactor coolant discharged from a ship. Credit for dilution was reduced to a factor of 1000 to be conservative. By setting the coolant discharge concentration limit at 100 times the Handbook 52 value for specific radionuclides listed, and taking credit for a 1000-fold dilution, the one-tenth criteria was met.

In January 1960, the NNPP release criteria were revised to be one-tenth of the limit of National Bureau of Standards Handbook 69, Reference 12. The Handbook 69 values were subsequently incorporated into Reference 6. 10CFR20 continues to serve as the commercial nuclear industry basis for radioactive effluents in air or water through the present. The standard instructions codified in 1965 for use by all NNPP activities were based on the limits of 10CFR20, to ensure consistency with commercial standards where practical.

Figure 5.1
Simplified Diagram of Typical
Radioactive Liquid Processing System



Between 1958 and May 1961, shore activities were allowed to dilute radioactive liquids to less than 3×10^{-5} µCi/ml (3×10^{4} pCi/l) prior to discharge. In May 1961, the Program required that radioactive liquids be treated by filtration and ion exchangers to minimize the dilution required to attain the 3×10^{-5} µCi/ml (3×10^{4} pCi/l) limit. In December 1965, requirements were modified to prefer additional treatment to attain the allowable concentrations in lieu of dilution.

In addition to the concentration limits discussed above, other limits and conditions were required, including total activity per year, total activity per shift, tidal conditions at the time of discharge, total gallons discharged, and proper authorizations. These NNPP limits and conditions were more conservative than any other agency's regulations at this time.

The tritium (hydrogen-3) concentration in reactor coolant is about 2×10^{-3} µCi/ml (2×10^{6} pCi/l) or less. This is below the 10CFR20 sanitary sewer release criteria for tritium which the Nuclear Regulatory Commission uses for sites it regulates. Any such water which entered the harbor would be rapidly diluted and become indistinguishable from background tritium levels, as discussed in Section 4.2.2. If any small volume spilled on land and went undetected, it would be quickly washed into the harbor (e.g., by rainwater, or possibly by entering the shallow ground water system which discharges into the harbor as discussed in Section 3.3.3.2). No environmental mechanism to concentrate this radionuclide exists.

During 1970, activities were directed to acquire the capability to collect and process reactor cooling water. In June of 1972, the Program regulations directed that discharges of processed liquids could only be made with specific approval of Naval Nuclear Propulsion Program headquarters. Since water was not collected from ships for processing by either tenders or shore-based facilities at HPA, this requirement did not apply to HPA; shipboard discharges to the harbor were prohibited.

5.1.1.2 **Liquid Discharges and Records**

Until 1973, HPA was occasionally used as a port for NNPP ships. Radiological maintenance was first performed on a nuclear-powered ship at HPA by Mare Island Naval Shipyard in 1985. No discharges of radioactive liquids to San Francisco Bay are known to have occurred during the five availabilities of NNPP ships at HPA. Liquids from in-port nuclear-powered ships may have been processed and discharged to the bay as described above prior to 1972. Since 1972, Naval activities at HPA have not intentionally discharged any liquids to the bay and have not requested permission to do so.

Although none of the original discharge permits are available, data concerning volume and total radioactivity discharged were summed and the values reported annually to NNPP headquarters by Mare Island Naval Shipyard (MINS). These values are shown in Table 5-1 for the period of use of the HPA drydock for NNPP ships from 1985 to 1989, and continuing through 1995; the values are totals for all NNPP activities throughout San Francisco Bay.

Table 5-1
Radioactive Liquid Released to San Francisco Bay
1985-1995

Year	Volume (Thousand Gallons)	Activity (Curies)
1995	<1	<0.001
1994	<1	<0.001
1993	<1	<0.001
1992	<1	<0.001
1991	<1	<0.001
1990	<1	<0.001
1989	<1	<0.001
1988	<1	<0.001
1987	<1	<0.001
1986	<1	<0.001
1985	<1	<0.001

Note: Activity is reported as cobalt-60 equivalent. Tritium and carbon-14 are excluded.

As shown in Table 5-1, the highest annual activity discharged at HPA during its maintenance of NNPP ships was <0.001 curie, which is less than the naturally occurring radioactivity in a cube of sea water 16 yards on a side (Reference 13). For the entire NNPP, annual discharges within 12 miles of land prior to 1973 ranged from 1 to 10 curies; total NNPP discharges (including at sea) have been 0.4 Ci/yr since about 1975 (less than 0.002 curie within 12 miles of land). Compared to the discharges from other nuclear programs and activities and to the millions of curies occurring naturally in the oceans, even the pre-1973 amount of radioactivity is small. Table 5-2 shows 1990 radioactivity discharges from commercial nuclear power plants, in comparison to the NNPP total within 12 miles of land. (Table 5-2 includes all radionuclides with a half-life of greater than 8 days).

Table 5-2
Environmental Releases (Curies) on Land or within Territorial Waters (Naval[1] vs. Civilian[2] Reactors)

AIRBORNE	
PEACH BOTTOM 2 & 3	11200
OCONEE 1, 2 & 3	8840
CRYSTAL RIVER 3	7310
SEQUOYAH 1 & 2	6070
WATERFORD 3	5730
BIG ROCK POINT 1	5550
VERMONT YANKEE 1	5070
MONTICELLO	2960
MILLSTONE 2	2890
INDIAN POINT 1 & 2	2230
SAN ONOFRE 1	1800
HADDAM NECK	1460
BRAIDWOOD 1	1420
JAMES A. FITZPATRICK	1350
BYRON 1 & 2	1240
PALO VERDE 3	1200
SAN ONOFRE 2 & 3	1160
BRUNSWICK 1 & 2	1120
EDWIN I. HATCH 1 & 2	1100
DAVIS - BESSE 1	1090
RIVER BEND 1	1030
BRAIDWOOD 2	1020
WOLF CREEK 1	999
NORTH ANNA 1 & 2	952
MAINE YANKEE	946
PILGRIM 1	907
COMANCHE PEAK 1	906
CALLAWAY 1	902
WNP - 2	890
HOPE CREEK 1	830
SUMMER 1	751
OYSTER CREEK 1	735
PALO VERDE 1	708
ARKANSAS ONE 1	700
TURKEY POINT 3	688
LASALLE 1 & 2	687
PALO VERDE 2	676
CALVERT CLIFFS 1 & 2	672
THREE MILE ISLAND 1	666
INDIAN POINT 3	626
ST. LUCIE 1	619
HARRIS 1	596
R. E. GINNA	595
TURKEY POINT 4	592
ST. LUCIE 2	534
CATAWBA 1	533
CATAWBA 2	533
MCGUIRE 1	518
MCGUIRE 2	518
FORT CALHOUN 1	459
SURRY 1 & 2	451
SALEM 1	313
MILLSTONE 3	211
TROJAN	206
ARKANSAS ONE 2	189
DONALD C. COOK 1 & 2	188
VOGTLE 1 & 2	188
COOPER	187
SOUTH TEXAS 1	172
NINE MILE POINT 2	163
FERMI 2	161
SALEM 2	149
GRAND GULF 1	136
PALISADES	121
MILLSTONE 1	117
YANKEE ROWE 1	113
ZION 1 & 2	110
SOUTH TEXAS 2	109
SEABROOK 1	107
JOSEPH M. FARLEY 1	87
PERRY 1	84
PRAIRIE ISLAND 1 & 2	83
BEAVER VALLEY 1 & 2	82
QUAD - CITIES 1 & 2	80
SUSQUEHANNA 1 & 2	72
DIABLO CANYON 1 & 2	56
DUANE ARNOLD	46
JOSEPH M. FARLEY 2	34
LIMERICK 1 & 2	34
DRESDEN 2 & 3	20
CLINTON 1	11
POINT BEACH 1 & 2	8
H. B. ROBINSON 2	7
KEWAUNEE	2
RANCHO SECO 1	0.2
BROWNS FERRY 1, 2 & 3	N/D
DRESDEN 1	N/D
FORT ST. VRAIN	N/D
HUMBOLDT BAY 3	N/D
LACROSSE	N/D
NINE MILE POINT 1	N/D
SHOREHAM 1	N/D
THREE MILE ISLAND 2	N/D

< NAVAL REACTORS <50

LIQUID (less tritium)	
MILLSTONE 2	8.76
SOUTH TEXAS 1	7.09
SOUTH TEXAS 2	5.72
SURRY 1 & 2	4.60
SALEM 2	3.14
OCONEE 1, 2 & 3	3.11
SALEM 1	3.00
DIABLO CANYON 1 & 2	2.80
HADDAM NECK	2.69
ZION 1	2.65
BEAVER VALLEY 1 & 2	2.55
MILLSTONE 3	2.47
ARKANSAS ONE 1	2.36
BRAIDWOOD 1	2.13
BRAIDWOOD 2	2.13
COOPER	2.04
MCGUIRE 1	2.00
MCGUIRE 2	2.00
DONALD C. COOK 1 & 2	1.61
HOPE CREEK 1	1.49
CALVERT CLIFFS 1 & 2	1.42
SEQUOYAH 1 & 2	1.22
BYRON 1 & 2	1.18
INDIAN POINT 1 & 2	1.06
VOGTLE 1 & 2	1.01
CATAWBA 1	0.978
CATAWBA 2	0.978
ZION 2	0.926
ST. LUCIE 1	0.827
FORT CALHOUN 1	0.805
ST. LUCIE 2	0.768
RIVER BEND 1	0.737
HARRIS 1	0.731
WATERFORD 3	0.730
DRESDEN 1, 2 & 3	0.712
NORTH ANNA 1 & 2	0.675
GRAND GULF 1	0.645
CRYSTAL RIVER 3	0.619
PERRY 1	0.610
BRUNSWICK 1 & 2	0.457
SAN ONOFRE 1	0.403
H. B. ROBINSON 2	0.360
SUMMER 1	0.356
LIMERICK 1 & 2	0.343
WOLF CREEK 1	0.315
INDIAN POINT 3	0.309
BROWNS FERRY 1, 2 & 3	0.302
EDWIN I. HATCH 1 & 2	0.301
ARKANSAS ONE 2	0.252
FERMI 2	0.218
KEWAUNEE	0.206
SAN ONOFRE 2 & 3	0.202
MAINE YANKEE	0.187
R. E. GINNA	0.150
TROJAN	0.144
DAVIS - BESSE 1	0.141
TURKEY POINT 3	0.141
TURKEY POINT 4	0.140
MILLSTONE 1	0.139
SUSQUEHANNA 1 & 2	0.134
PRAIRIE ISLAND 1 & 2	0.130
QUAD - CITIES 1 & 2	0.113
JOSEPH M. FARLEY 2	0.083
JOSEPH M. FARLEY 1	0.075
LACROSSE	0.069
NINE MILE POINT 2	0.063
CALLAWAY 1	0.039
BIG ROCK POINT 1	0.036
JAMES A. FITZPATRICK	0.027
CLINTON 1	0.025
LASALLE 1 & 2	0.025
THREE MILE ISLAND 1	0.024
PILGRIM 1	0.016
WNP - 2	0.015
PEACH BOTTOM 2 & 3	0.014
COMANCHE PEAK 1	0.012
POINT BEACH 1 & 2	0.012
PALISADES	0.008
HUMBOLDT BAY 3	0.006
YANKEE ROWE 1	0.004
SEABROOK 1	0.002
NINE MILE POINT 1	0.00195
RANCHO SECO 1	0.00021
THREE MILE ISLAND 2	0.00018
FORT ST. VRAIN	0.00008
OYSTER CREEK 1	0.00007
DUANE ARNOLD	N/D
MONTICELLO	N/D
PALO VERDE 1	N/D
PALO VERDE 2	N/D
PALO VERDE 3	N/D
SHOREHAM 1	N/D
VERMONT YANKEE 1	N/D

< NAVAL REACTORS <0.002

1. Naval reactors include 4 land based prototypes and over 120 ships. Total Program releases are comparable to commercial reactor releases listed above.
2. Source: U. S. Nuclear Regulatory Commission report NUREG/CR - 2907, Vol. 11, October 1993.

From 1985 through 1995, total reported annual discharges (i.e., inadvertent discharges to the bay) from all NNPP activities in San Francisco were reported to be less than 1000 gallons and less than 0.001 curie. This volume primarily originates from disconnecting underwater joints between collection facilities and nuclear submarines. These lines are blown down prior to disconnection, but some residual water remains at low points in hard piping. Since the disconnection is made by divers, there is no way to measure the amount of water residual in the hard piping connected to the ship. (It is not likely this ever occurred at HPA.) The 1000 gallons is a very conservative volume. In most years, the volume actually released is much less than 1000 gallons. The "less than 0.001 curie" reported is based on a total discharge of 1000 gallons, and is also very conservative.

5.1.2 **Air Exhausted from Radiological Facilities**

Radiological work area (e.g., glove bag) exhaust systems used on NNPP ships at HPA were equipped with High Efficiency Particulate Air (HEPA) filters.

Records show that radiological monitoring of ventilation systems at Naval facilities in the San Francisco area was performed and documented as early as 1972, to detect air at concentrations of 1×10^{-9} µCi/ml (1 pCi/l), the regulatory limit for occupational exposure. Reference 10 and its predecessors indicate that monitoring has been required since 1969 at all exhaust stacks of Naval facilities which could have discharged airborne radioactivity.

The NNPP soon decided this was not sufficiently sensitive for air exhaust analyses. In 1973 an Environmental Monitoring System consisting of a vacuum pump, filter holder, differential pressure gauges, totalizing hourmeter, and connecting tubing, was installed at each HEPA filter exhausting to the environment from radiologically controlled facilities. A simplified diagram of this system is shown in Figure 5.2. At the same time, the analysis procedure was revised to require a minimum detectable activity (MDA) of less than 2×10^{-14} µCi/ml (2×10^{-5} pCi/l). Actual MDAs have generally been lower than this, and most analysis results are "less than MDA." The low exhaust air radioactivity concentrations shown in Table 5-3 are expected to have existed since the beginning of NNPP work, since HEPA filtering policies have not been changed. Table 5-3 includes data for all San Francisco Bay facilities through 1995.

Sampling probe location is determined by obtaining a velocity profile across the duct, downstream of the HEPA filter. A uniform velocity distribution indicates turbulent flow, assuring adequate mixing and entrainment of particulates to permit single point sampling. If the velocity profile does not permit single point sampling (laminar flow), an array of sampling probes could be located in accordance with ANSI N13.1-69. All NNPP systems are configured to permit single point sampling (turbulent flow).

Figure 5.2
Simplified Diagram of Environmental Monitoring System
(Air Sampling)

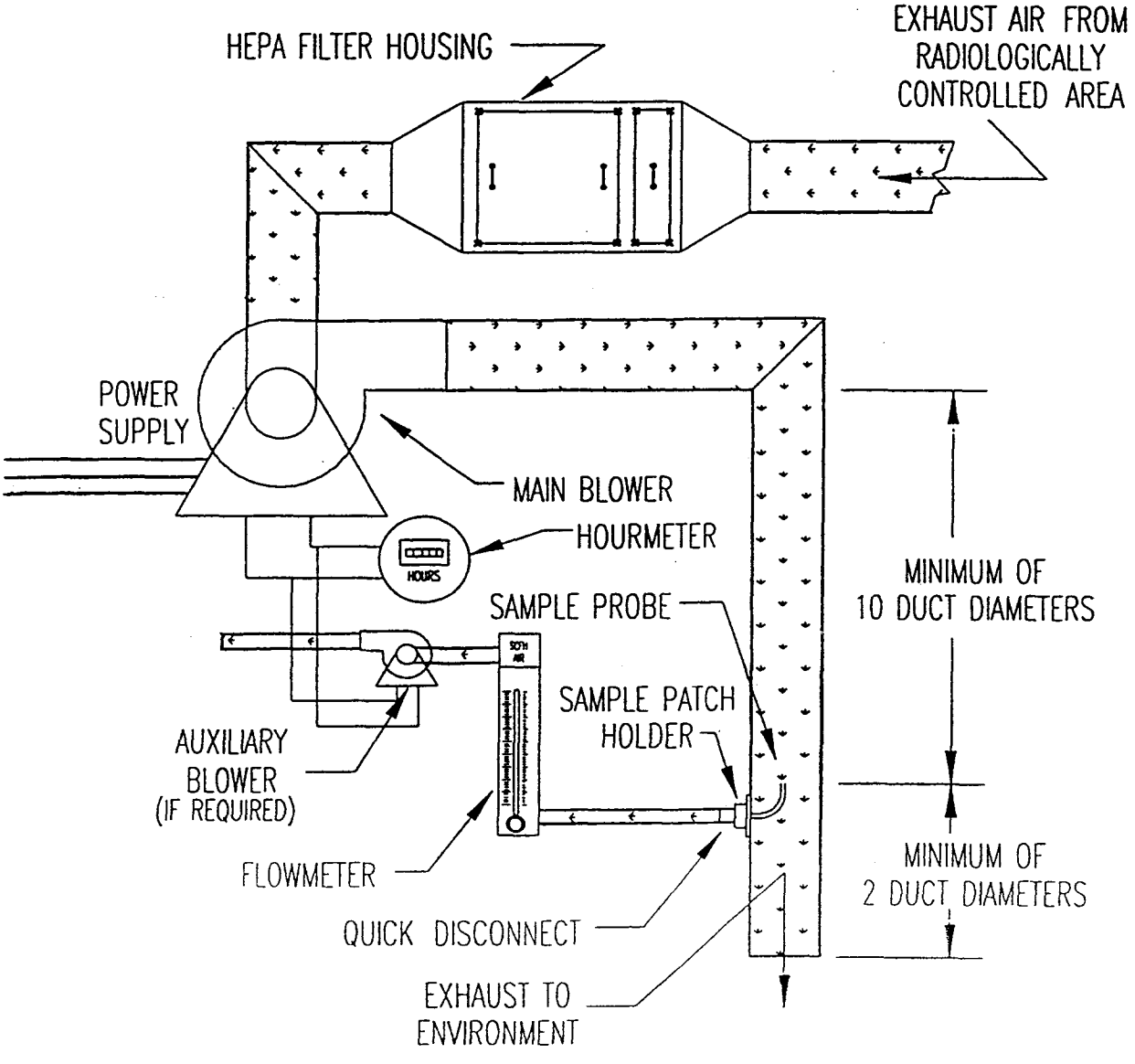


Table 5-3
Airborne Particulate Radioactivity in Air Exhausted from Radiological Facilities vs. Background Radioactivity in Air for All Naval Facilities in the San Francisco Bay Area 1973-1995 (a)

Year	Average Facility Exhaust Air Activity Concentration µCi/ml	Total Airborne Radioactivity Discharged from Facilities µCi/yr	Background Air Activity Concentration µCi/ml (b)	Total Activity if Background Air had been Discharged µCi/yr
1995	1.4×10^{-15}	0.26	3.6×10^{-15}	0.29
1994	2.9×10^{-15}	2.4	3.5×10^{-15}	2.6
1993	6.7×10^{-15}	2.9	9.0×10^{-15}	5.6
1992	8.0×10^{-16}	0.4	1.2×10^{-14}	6.1
1991	1.6×10^{-15}	0.5	1.5×10^{-14}	7.7
1990	1.4×10^{-15}	0.6	1.5×10^{-14}	8.4
1989	1.2×10^{-15}	0.7	1.7×10^{-14}	12.0
1988	8.0×10^{-16}	0.2	1.2×10^{-14}	12.4
1987	8.0×10^{-16}	0.7	1.5×10^{-14}	12.8
1986	1.4×10^{-15}	1.3	3.1×10^{-14}	45.2
1985	6.0×10^{-16}	0.4	1.1×10^{-14}	6.9
1984	8.0×10^{-16}	0.5	1.3×10^{-14}	8.8
1983	3.8×10^{-15}	3.5	1.6×10^{-14}	14.7
1982	4.0×10^{-15}	2.8	1.7×10^{-14}	11.3
1981	5.0×10^{-15}	2.7	6.7×10^{-14}	35
1980	3.0×10^{-15}	3.2	2.7×10^{-14}	23
1979	3.0×10^{-15}	3.1	1.9×10^{-14}	18
1978	4.0×10^{-15}	4.0	3.9×10^{-14}	43
1977	5.0×10^{-15}	5.2	7.5×10^{-14}	85
1976	4.0×10^{-15}	4.8	6.4×10^{-14}	71
1975	4.0×10^{-15}	3.2	4.0×10^{-14}	40
1974	5.0×10^{-15}	3.9	1.3×10^{-13}	102
1973	3.9×10^{-15}	1.9	1.6×10^{-14}	8.0

Notes:

(a) Numerical data was not reported until 1973. HEPA filtering procedures were identical in earlier years, so exhaust air radioactivity levels are expected to have been about the same prior to 1973. Actual exhaust air concentrations are expected to have been lower than reported here, since most analysis results were below detectability and MDA values were included in each year's average for "less than MDA" results.
(b) Measured at Mare Island Naval Shipyard.

The sampling probe inlet velocity is adjusted to provide isokinetic flow. This assures that a representative sample will be obtained.

The systems are checked weekly to verify that the flow rate is within specifications and the differential pressure across the filter is within prescribed limits. At a minimum, the sampling filter must be changed annually. In practice, much more frequent changes are required due to dust loading of the sample filter.

Any temporary monitoring systems used at HPA by MINS in support of radiological work would have been analyzed by MINS. In 1981, as a cross-check of analysis results, an independent Department of Energy (DOE) laboratory began sending MINS a simulated Environmental Monitoring System air filter for comparison of laboratory analysis results. MINS analysis results were consistent with DOE laboratory results, as shown in Table 6-4.

Table 5-3 summarizes the results of air exhaust monitoring. The table includes a comparison of background activity data discharged from the same exhaust systems, which was computed by substituting the background air activity during the respective sampling period for the actual measured activity from the exhaust systems. In each year, the activity of air exhausted from radiological facilities has contained less total radioactivity than the naturally occurring radioactivity in an equal amount of air from the environment.

These data verify that air exhausts of ships at HPA have been significantly cleaner than the air in the environment, from a radiological perspective.

EPA regulations for radionuclide emissions from non-DOE Federal facilities, including from Navy Facilities, are contained in Title 40, Code of Federal Regulations, Part 61 (40CFR61) Subpart I.

As part of the 40CFR61 regulations, activities are required to report emissions unless the amounts released are less than 10 percent of the standards. To assist activities in assessing their facilities, the EPA has provided a computer code called COMPLY. Mare Island Naval Shipyard has run this program for San Francisco Naval facilities using site-specific parameters required for Level 4 analysis using COMPLY. For 1994, when the HPA drydock used for nuclear-powered ships (Drydock 4) was released from the NNPP, the COMPLY results were less than 10 percent of the standards, and Naval facilities at San Francisco were exempt from the requirements for reporting in accordance with 40CFR61.

The NESHAP 40CFR61 calculations demonstrate an exposure level to on-site residents (and hence the general public) of less than 1 mrem/yr, including the contributions from trace levels of fission product gases and gaseous carbon-14 products as discussed in Sections 4.2 and 4.2.3. Noble gases such as isotopes of argon, krypton, or xenon do not accumulate in the environment and are therefore not a potential candidate for site remediation. Also, even if radioiodines had ever been released in significant quantities (which they haven't been), they would not constitute a potential remediation issue due to their short half lives. Finally, carbon-14 does not accumulate in the environment, as discussed in Section 4.2.3.

5.1.3 **Reports of Inadvertent Releases**

Naval Nuclear Propulsion Program regulations require that formal reports be submitted to NNPP headquarters by activities when inadvertent releases of radioactivity to uncontrolled areas, to personnel, or to the environment occur. These "incident reports" have been required since the inception of the Program. HPA has a listing of these reports dating back to 1985.

An extensive search for archive copies of incident reports was conducted. Only one report was related to potential radioactivity releases to the environment. Comprehensive reviews of all available detailed records were performed for this HRA. Table 5-4 summarizes data obtained during these reviews. These reviews verified that the affected areas were surveyed and sampled as required by regulations and that the areas were properly released from radiological controls. The release criteria for surface contamination are less than 450 pCi/100 cm^2 by swipe analysis as discussed in Section 4.4, and less than 450 pCi per 20 cm^2 scanning probe. The release criteria for soil/concrete at a spill site was formerly less than 30 pCi/g; several years ago it was reduced to less than 1 pCi/g cobalt-60 unless NNPP headquarters approves otherwise on a case basis. No such exceptions apply at HPA. Using NNPP sampling and analysis procedures, these surface and soil release criteria are at the limit of detectability above background.

That no significant radioactivity has accumulated in the marine environment is confirmed by harbor water, sediment, and biota sample results reported elsewhere in this HRA.

Table 5-4
Summary of Reports of Potential
Radioactivity Releases to the Environment

Date	Location	Volume	Activity
06/08/87	Ship in Drydock 4	N/A	N/A
Summary: A primary valve operating tool could not be located.			
Response: An exhaustive search and tool box inventory, and interviews with personnel, did not locate the tool. Personnel reported that the tool had been frisked for radioactivity before it was missing; no radioactivity above background was detected. The curie content of the tool was estimated as not measurable, and the potential impact on the general public and the environment was estimated to be negligible.			

5.2 Low-Level Solid Radioactive Waste Disposal

5.2.1 Policy

Solid low-level radioactive waste is generated during operation and maintenance of Naval nuclear-powered ships. This low level waste consists primarily of contaminated rags, plastic bags, paper, filters, ion exchange resin, and scrap materials. To maintain accountability, strict controls over these materials are implemented. These controls include serialized tagging and marking, and signatures by radiologically trained personnel to document transfers of materials. Solid radioactive waste materials are packaged in strong tight containers and shielded as necessary.

From the inception of the Program, on-site disposal of radioactive solid waste has been prohibited. This policy was described in early reports such as "Radioactive Waste Disposal from U.S. Naval Nuclear Powered Ships," January 1959, Reference 14. Radioactive solid waste was shipped to disposal sites operated or authorized by the Atomic Energy Commission (AEC). In the early years of the Program, this included some AEC-authorized ocean disposal sites. Waste from HPA was transferred to Mare Island Naval Shipyard and Naval Air Station (NAS) Alameda for disposal. When commercially operated sites licensed by the AEC or a state under agreement with the AEC became available, Navy solid waste was sent to these sites. Currently, such waste is shipped to disposal sites licensed by the U.S. Nuclear Regulatory Commission or a state under agreement with the U.S. Nuclear Regulatory Commission.

The quantity of solid radioactive waste generated and shipped in any one year from HPA depended on the amount and type of support work performed that year.

All HPA radioactive shipments in the NNPP contained only low-level radioactivity classified under Department of Transportation regulations as low specific activity or limited quantity shipments. The predominant radionuclide associated with these shipments is cobalt-60 in the form of insoluble metallic oxide corrosion products attached to surfaces of materials inside shipping containers. Most low-level shipments are made by ship and truck. Air transport is used no more than a few times per year for the NNPP. These air shipments involve only very low levels of radioactivity and are restricted to cargo aircraft.

The policies and practices used successfully for over 40 years in managing radioactive materials and radioactive waste continue to be used currently. Reference 10 discusses and also illustrates the overall performance of the Program since 1961 in managing radioactive waste.

Facilities continue to be prohibited from disposing of radioactive waste on site. No Navy sites have active or inactive disposal areas for NNPP radioactive materials.

HPA had agreements with Naval shipyards to dispose of radioactive waste. Naval bases have only limited storage areas for staging waste for disposal. Mare Island Naval Shipyard (MINS) disposed of waste from HPA. Waste totals were included in the quantity of waste reported by MINS, but not differentiated as to origin. The Program policies of minimizing waste at the point of generation and then disposing of it as soon as processing and packaging are completed continue to be applied.

5.2.2 **Records**

The annual summary of solid waste disposal is included with the annual environmental monitoring reports prepared by the Naval Nuclear Propulsion Program. This summary includes all radioactive waste from nuclear-powered ships at HPA, which is sent to burial facilities licensed by the U.S. Nuclear Regulatory Commission or a state. Although specific details of amount and content of such waste are not available, personnel interviews reveal that radioactive waste had been transferred to Mare Island Naval Shipyard (MINS). Puget Sound Naval Shipyard has custody of archive copies of annual solid radioactive waste summary reports for HPA. A synopsis of annual solid radioactive waste data derived from available MINS records through 1994, when the HPA drydock for nuclear-powered ships was released from the NNPP, is contained in Table 5-5.

MINS disposed of NNPP waste (including that generated at HPA) at Beatty, Nevada from 1961 through 1992 with some waste disposed of at the Hanford, Washington commercial radioactive waste disposal site. From 1993 until its closure, MINS disposed of all solid radioactive waste at Barnwell, South Carolina and Hanford, Washington.

Table 5-5
Summary of Solid Radioactive Waste Disposal from Mare Island Naval Shipyard 1966-1994

Year	Number of Containers	Volume (Cubic Feet)	Contractor (a)	Disposal Site (a)
1994	301	30157	USE/CNSI	HW/BSC
1993	163	9547	CNSI	BSC
1992	189	7978	USE	BN
1991	232	4848	USE	BN
1990	214	5329	USE	BN
1989	362	5198	USE	BN
1988	251	5588	USE	BN
1987	260	10054	USE	BN
1986	63	2383	USE	BN
1985	(b)	7000	USE	BN
1984	137	4641	USE	BN
1983	199	4955	USE	BN
1982	105	2243	USE	BN
1981	194	2419	USE	BN
1980	(b)	6000	NEC	BN
1979	(b)	2000	SWNC	BN
1978	(b)	11000	SWNC	BN
1977	(b)	7000	SWNC	BN
1976	(b)	8000	NEC/SWNC	BN
1975	(b)	11000	NEC	BN
1974	(b)	7000	NEC	BN
1973	(b)	6000	NEC	BN
1972	(b)	9000	NEC	BN
1971	(b)	22000	NEC	BN
1970	(b)	12000	NEC	BN
1969	(b)	8000	NEC	BN
1968	(b)	7600	NEC	BN
1967	(b)	9200	NEC	BN
1966	(b)	9200	NEC	BN

Notes: The majority of the waste was generated at MINS; work at HPA contributed a small amount to the total (expected to have been 1985-1989 only).

(a) Abbreviations used:
- USE: U.S. Ecology Inc., Beatty, Nevada.
- CNSI: Chem-Nuclear Systems, Inc., Barnwell, South Carolina.
- SWNC: South West Nuclear Company, Pleasanton, California.
- NEC: Nuclear Engineering Company, Walnut Creek, California.
- HW: Hanford, Washington.
- BSC: Barnwell, South Carolina.
- BN: Beatty, Nevada Burial Facility.

(b) Data/information not available.

The existence of waste disposal records dating back to 1966 and continuing through 1994, along with the prohibition of disposing of waste on-site, provide evidence that no solid radioactive waste has been disposed of on site property.

5.3 Mixed Waste

Mixed waste (waste which is both hazardous and contaminated with low level radioactivity) has been generated during repair of nuclear-powered ships at some NNPP facilities. None was produced at HPA.

5.4 Release of Facilities and Equipment Previously Used for Radiological Work

Naval Nuclear Propulsion Program regulations require that activities engaged in Naval nuclear propulsion plant work compile and maintain lists of facilities, areas, and equipment that have been used in support of radiological work. These regulations further require that extensive radiological surveys be conducted when these radiological work or storage areas will no longer be used or when the area, facility, or equipment is being released from radiological control.

Such surveys include those using a gamma scintillation type meter and beta-gamma frisk surveys. Solid material samples are analyzed with a high-purity germanium detector coupled to a multichannel analyzer. Samples are taken in defined grids. Any radioactivity detected by surveys or samples is removed and the area resurveyed or resampled until levels comparable to background are attained. Release criteria are discussed in Sections 4.4 and 5.1.3.

Results of surveys and sample analyses are formally documented and archived. For those areas being permanently released, a written report describing the area, radiological history, surveys and sampling protocol, tabulated results, and conclusions is forwarded to NNPP headquarters.

Drydock 4, the only previous NNPP radiologically controlled area at HPA, was radiologically released by the NNPP in 1994 as discussed in Reference 15. Areas of the drydock floor adjacent to nuclear-powered ships were used for the placement of portable radioactive liquid waste collection drums and for temporary radioactive material storage. Radioactive liquid waste drums were controlled by technical work documents which were approved by radiologically-trained MINS engineering personnel. All temporary radioactive material storage areas required the written approval of the MINS Director, Radiological Control Office.

When a radioactive liquid waste tank is relocated or a temporary radioactive material storage area is disestablished, beta-gamma radiological surveys are performed prior to removing signs and barriers. The area must meet the NNPP limits of less than 450 pCi/100cm^2 for swipe samples, or less than 450 pCi/20 cm^2 using a scanning probe, to be released for general use. Even then, the area is included on the list of those areas requiring permanent release as described above. In the case of Drydock 4 at HPA, solid samples were also analyzed following the last NNPP use of the drydock in 1989, using release criteria as discussed in Section 5.1.3.

Radiological equipment, including portable work and storage enclosures, are maintained under the control of radiological control personnel until permanently released as described above. In addition, if the equipment has any crevices which could trap loose surface contamination, the item must be bulk-counted before release or be disposed of as solid radioactive waste.

An example of the large-scale release of prior NNPP radiological facilities occurred when the NNPP left Ingalls Shipbuilding in Pascagoula, Mississippi. From 1958 to 1980, Ingalls Shipbuilding was engaged in the construction and overhaul of Naval nuclear-powered ships. The shipyard radiological facilities which supported this work were deactivated between 1980 and 1982. Extensive radiological decommissioning surveys were performed to verify the effectiveness of deactivation. Direct radiological surveys were performed on over 274,000 square feet of building and facility surfaces. Over 11,000 samples of these surfaces as well as soil, ground cover, and concrete were taken from all areas where radioactive work was previously performed. These samples were analyzed using sensitive laboratory equipment. In addition, both the State of Mississippi and the Environmental Protection Agency (Reference 16) performed overcheck surveys of the deactivated facilities. After these surveys were completed, the Ingalls facilities were released for unrestricted use.

As at Ingalls, extensive radiological decommissioning surveys were performed at Mare Island and Charleston Naval Shipyards to verify the removal of radioactive material. These shipyards were deactivated following the 1993 round of the Base Realignment and Closure process. At each shipyard, direct radiological surveys on over 5,000,000 square feet of building and facility surfaces and analyses of over 40,000 samples of soil, ground cover, and concrete using sensitive laboratory equipment detected no cobalt-60 other than trace concentrations in a few localized areas. Simple, proven cleanup methods were used to remediate these areas. The total amount of NNPP radioactivity removed from the environment at each shipyard was equivalent to that in a single home smoke detector (2 to 3 μCi). Both shipyards were released for unrestricted use with respect to NNPP radioactivity by the operational closure date of April 1, 1996, with state and EPA agreement.

Personnel who subsequently occupy these facilities will not receive detectable radiation exposure above natural background levels. This relatively rapid and inexpensive remediation effort was only possible due to the NNPP policy of operating its radiological facilities in a manner which does not impact the environment.

5.5 **Current Radiological Facilities**

Naval nuclear propulsion plant work at HPA was last performed in 1989, and the site was released with respect to the NNPP in 1994 as discussed in Reference 15. There are no NNPP radiological work or storage areas at HPA, and there are no areas within HPA where radioactivity associated with the NNPP exists above natural background levels.

6.0 ENVIRONMENTAL MONITORING PROGRAM

Radiological environmental monitoring was conducted at Hunters Point Annex since the beginning of its involvement with Naval nuclear-powered ships, by Mare Island Naval Shipyard from 1966 through the second quarter of 1995. This monitoring consisted of analyzing harbor sediment, water, and marine life samples for radioactivity associated with Naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities, and related monitoring. The scope and analysis methods of monitoring are sensitive enough to identify environmental radioactivity from various sources, such as that due to airborne nuclear tests in past years. Environmental samples are also checked at least annually by a U.S. Department of Energy laboratory to ensure analytical procedures are correct and standardized within the NNPP.

Sections 2.3.1 and 4.2.1 discuss the basis for cobalt-60 being the primary radionuclide of interest for the NNPP.

6.1 Harbor Environmental Records

Harbor environmental data consisting of sediment, water, and marine life sample analysis data are applicable to the surface water pathway.

6.1.1 Sediment Sampling

The earliest published report that included Navy sediment sampling data is contained in Reference 17. Table II of Reference 17 shows that in 1966, 437 samples were taken at San Francisco Bay facilities. Periodically, two representative samples were sent to the U.S. Public Health Service Southeastern Radiological Health Laboratory for independent analysis. As an additional intercomparison, some randomly selected samples were sent to a U.S. Atomic Energy Commission laboratory for analysis.

In 1966, the NNPP specified a uniform Program environmental monitoring protocol. Records of quarterly sediment samples are available since 1966.

Beginning in 1966, the NNPP has published an annual report of environmental monitoring and waste disposal throughout the Program. These reports have been made available to Federal regulatory agencies, state governments, and the general public. Reference 10 is the latest in this series of reports.

Each of the annual reports contains sediment sampling data. Data for sediment sampling results reported annually by Mare Island Naval Shipyard (MINS) for Hunters Point Annex are included in Table 6-1.

Table 6-1
Gamma Radioactivity Concentration in Hunters Point Annex Sediment Samples 1966-1995

		No. of Samples with Co-60 Energy Range Activity			Gross Gamma >0.1 MeV		Cobalt-60 Energy Range
Year	Quarter	<10 pCi/cm² (a)	10-100 pCi/cm²	>100 pCi/cm²	Average pCi/cm²	High/Low pCi/cm²	High/Low pCi/cm² (b)
1966	1	47	0	0	6.1	13.7 - 1.5	3.0 - <0.3
	2	47	0	0	3.8	6.0 - 1.2	(c)
	3	47	0	0	2.4	5.8 - NDA	(c)
	4	47	0	0	2.6	3.9 - NDA	(c)
1967	1	47	0	0	4.4	11.0 - 1.3	(c)
	2	47	0	0	5.0	7.5 - 1.0	(c)
	3	48	0	0	3.1	4.4 - 1.8	(c)
	4	47	0	0	2.7	4.1 - NDA	(c)
1968	1	47	0	0	2.8	9.1 - 1.4	0.7 - <0.3
	2	47	0	0	4.6	8.4 - 2.9	0.7 - <0.3
	3	47	0	0	3.4	5.7 - NDA	0.6 - <0.3
	4	47	0	0	3.5	4.9 - 2.2	0.6 - <0.3
1969	1	47	0	0	3.1	4.9 - NDA	0.7 - <0.3
	2	47	0	0	3.9	5.2 - 2.6	0.5 - <0.3
	3	47	0	0	3.7	4.8 - 2.5	0.4 - <0.3
	4	47	0	0	3.5	4.7 - NDA	0.7 - <0.3
1970	1	47	0	0	3.7	5.1 - 2.4	0.7 - <0.3
	2	47	0	0	3.7	5.2 - 1.5	0.7 - <0.3
	3	47	0	0	4.4	6.1 - 1.9	0.7 - <0.3
	4	47	0	0	3.5	4.5 - NDA	0.5 - <0.3

Notes:

(a) From 1966 to 1970, the standard reporting requirements were in units of μμCi/cm². The above table has been changed to pCi/cm² since μμCi and pCi are the same unit. There is no direct conversion from cm² to gram without knowing the number of dredge loads needed to obtain a sample. This was corrected in 1971 by reporting pCi/g.

(b) Values preceded by "<" symbols are the minimum detectable levels (cobalt-60 energy range), which are expressed at the 90% confidence level. Sample analysis results were less than these values, which varied from sample to sample and location to location due to statistical fluctuations.

(c) Data not available.

NDA = No detectable activity.

Table 6-1 (continued)
Gamma Radioactivity Concentration
in Hunters Point Annex Sediment Samples
1966-1995

		No. of Samples with Co-60 Energy Range Activity			Gross Gamma >0.1 MeV		Cobalt-60 Energy Range
Year	Quarter	<3 pCi/g	3-30 pCi/g	>30 pCi/g	Average pCi/g	High/Low pCi/g	High/Low pCi/g (a)
1971	1	47	0	0	1.3	1.9 - 1.1	0.6 - <0.4(b)
	2	27	0	0	1.4	1.7 - 1.1	0.5 - <0.4(b)
	3	27	0	0	1.3	1.6 - 1.0	0.3 - <0.1
	4	27	0	0	1.1	1.4 - 0.8	0.1 - <0.1
1972	1	27	0	0	1.2	1.6 - 0.9	(c)
	2	27	0	0	1.5	2.8 - 0.7	(c)
	3	27	0	0	1.4	2.0 - 0.8	0.2 - <0.1
	4	27	0	0	1.4	2.2 - 0.9	0.1 - <0.1
1973	1	14	0	0	1.2	1.4 - 1.1	<0.1 - <0.1
	2	14	0	0	1.4	1.6 - 1.2	0.1 - <0.1
	3	14	0	0	1.5	2.0 - 1.2	0.1 - <0.1
	4	14	0	0	1.1	1.6 - 0.6	<0.4 - <0.4
1974	1	14	0	0	0.9	1.1 - 0.7	<0.4 - <0.4
	2	14	0	0	1.0	1.5 - 0.6	<0.4 - <0.4
	3	14	0	0	0.9	1.0 - 0.8	<0.4 - <0.4
	4	13	0	0	1.1	1.8 - 0.7	<0.3 - <0.3
1975	1	12	0	0	1.0	1.2 - 0.7	<0.3 - <0.3
	2	13	0	0	1.1	1.2 - 0.8	<0.3 - <0.3
	3	14	0	0	0.9	1.2 - 0.6	<0.3 - <0.3
	4	14	0	0	0.8	1.0 - 0.6	<0.3 - <0.3
1976	1	13	0	0	0.7	0.9 - 0.5	<0.3 - <0.3
	2	14	0	0	0.9	1.1 - 0.7	<0.3 - <0.3
	3	13	0	0	0.8	1.0 - 0.7	<0.3 - <0.3
	4	13	0	0	0.8	1.0 - 0.6	<0.3 - <0.3
1977	1	13	0	0	0.9	1.0 - 0.7	<0.3 - <0.3
	2	14	0	0	0.9	1.1 - 0.7	<0.3 - <0.3
	3	14	0	0	0.8	1.0 - 0.5	<0.3 - <0.3
	4	12	0	0	0.8	1.1 - 0.6	<0.3 - <0.3

Notes:

(a) Values preceded by "<" symbols are the minimum detectable levels (cobalt-60 energy range), which are expressed at the 90% confidence level. Sample analysis results were less than these values, which varied from sample to sample and location to location due to statistical fluctuations.
(b) Cobalt-60 energy range for the first and second quarters of 1971 was reported as pCi/cm^2.
(c) Data not available.

Table 6-1 (continued)
Gamma Radioactivity Concentration
in Hunters Point Annex Sediment Samples
1966-1995

		No. of Samples with Co-60 Energy Range Activity			Gross Gamma >0.1 MeV		Cobalt-60 Energy Range	Specific Cobalt-60
Year	Quarter	<3 pCi/g	3-30 pCi/g	>30 pCi/g	Average pCi/g	High/Low pCi/g	High/Low pCi/g	High/Low pCi/g (a)
1978	1	14	0	0	0.8	1.0 - 0.7	0.4 - 0.3	<0.1 - <0.1
	2	14	0	0	1.0	1.1 - 0.9	0.5 - 0.3	<0.2 - <0.1
	3	14	0	0	0.9	1.0 - 0.8	0.4 - 0.3	<0.2 - <0.1
	4	14	0	0	0.9	1.1 - 0.7	0.4 - 0.3	<0.1 - <0.1
1979	1	14	0	0	0.9	1.1 - 0.8	0.4 - 0.3	<0.1 - <0.1
	2	14	0	0	0.9	1.1 - 0.8	0.5 - 0.3	<0.1 - <0.1
	3	14	0	0	0.9	1.0 - 0.8	0.5 - 0.3	<0.1 - <0.1
	4	14	0	0	0.9	1.0 - 0.7	0.5 - 0.3	<0.1 - <0.1
1980	1	14	0	0	0.9	1.2 - 0.7	0.5 - 0.3	<0.1 - <0.1
	2	14	0	0	0.9	1.0 - 0.8	0.4 - 0.3	<0.1 - <0.1
	3	14	0	0	0.9	1.1 - 0.7	0.6 - 0.3	<0.1 - <0.1
	4	14	0	0	0.9	1.2 - 0.7	0.7 - 0.3	<0.1 - <0.1
1981	1	14	0	0	0.9	1.0 - 0.7	0.5 - 0.3	<0.1 - <0.1
	2	14	0	0	1.0	1.2 - 0.8	0.4 - 0.3	<0.1 - <0.1
	3	13	0	0	0.9	1.0 - 0.7	0.5 - 0.3	<0.1 - <0.1
	4	14	0	0	0.9	1.0 - 0.7	0.5 - 0.3	<0.1 - <0.1
1982	1	14	0	0	0.8	0.9 - 0.8	(b)	(b)
	2	14	0	0	0.9	1.0 - 0.8	0.5 - 0.3	<0.1 - <0.1
	3	14	0	0	0.9	1.2 - 0.8	0.6 - 0.3	<0.1 - <0.1
	4	14	0	0	0.8	0.9 - 0.7	0.5 - 0.3	<0.1 - <0.1
1983	1	14	0	0	0.9	1.0 - 0.8	0.4 - 0.2	<0.1 - <0.1
	2	14	0	0	0.8	0.9 - 0.8	0.4 - 0.3	<0.1 - <0.1
	3	14	0	0	0.8	0.9 - 0.8	0.4 - 0.3	<0.1 - <0.1
	4	14	0	0	0.8	0.9 - 0.7	(b)	(b)
1984	1	14	0	0	0.9	1.0 - 0.8	0.5 - 0.3	<0.1 - <0.1
	2	14	0	0	0.9	1.1 - 0.8	0.5 - 0.3	<0.2 - <0.1
	3	14	0	0	0.9	1.1 - 0.7	(b)	(b)
	4	14	0	0	0.8	1.2 - 0.6	0.5 - 0.2	<0.1 - <0.1
1985	1	14	0	0	0.8	1.2 - 0.7	0.5 - 0.3	<0.1 - <0.1
	2	14	0	0	0.9	1.2 - 0.6	0.5 - 0.3	<0.1 - <0.1
	3	14	0	0	0.9	1.0 - 0.5	0.5 - 0.2	<0.1 - <0.1
	4	14	0	0	0.9	1.0 - 0.8	0.5 - 0.3	<0.1 - <0.1
1986	1	14	0	0	0.9	1.1 - 0.8	0.6 - 0.3	<0.1 - <0.1
	2	14	0	0	1.0	1.7 - 0.8	0.6 - 0.3	<0.1 - <0.1
	3	14	0	0	0.9	1.2 - 0.8	0.7 - 0.3	<0.1 - <0.1
	4	14	0	0	0.9	1.2 - 0.8	0.6 - 0.3	<0.1 - <0.1
1987	1	14	0	0	0.8	1.0 - 0.7	0.4 - 0.3	<0.1 - <0.1
	2	14	0	0	0.8	1.0 - 0.7	0.5 - 0.3	<0.1 - <0.1
	3	14	0	0	0.9	1.2 - 0.7	0.6 - 0.3	<0.1 - <0.1
	4	14	0	0	0.8	1.0 - 0.7	0.5 - 0.3	<0.1 - <0.1
1988	1	14	0	0	1.0	1.2 - 0.9	0.6 - 0.4	<0.1 - <0.1
	2	14	0	0	0.9	1.3 - 0.6	0.6 - 0.3	<0.1 - <0.1
	3	14	0	0	0.9	1.3 - 0.8	0.6 - 0.3	<0.1 - <0.1
	4	14	0	0	0.9	1.1 - 0.7	0.5 - 0.3	<0.1 - <0.1

Table 6-1 (continued)
Gamma Radioactivity Concentration
in Hunters Point Annex Sediment Samples
1966-1995

		No. of Samples with Co-60 Energy Range Activity			Gross Gamma >0.1 MeV		Cobalt-60 Energy Range	Specific Cobalt-60
Year	Quarter	<3 pCi/g	3-30 pCi/g	>30 pCi/g	Average pCi/g	High/Low pCi/g	High/Low pCi/g	High/Low pCi/g (a)
1989	1	14	0	0	0.9	1.3 - 0.7	0.5 - 0.3	<0.1 - <0.1
	2	14	0	0	1.0	1.3 - 0.9	0.6 - 0.3	<0.2 - <0.1
	3	14	0	0	1.0	1.2 - 0.9	0.6 - 0.4	<0.2 - <0.1
	4	14	0	0	0.8	1.1 - 0.7	0.5 - 0.3	<0.2 - <0.1
1990	1	14	0	0	0.9	1.2 - 0.8	0.5 - 0.3	<0.11 - <0.03
	2	14	0	0	1.1	1.5 - 0.9	0.7 - 0.4	<0.15 - <0.05
	3	14	0	0	0.9	1.2 - 0.7	0.5 - 0.4	<0.13 - <0.06
	4	14	0	0	0.9	1.4 - 0.8	0.6 - 0.3	<0.15 - <0.03
1991	1	14	0	0	0.9	1.3 - 0.7	0.6 - 0.3	<0.09 - <0.03
	2	14	0	0	0.9	1.2 - 0.8	0.5 - 0.3	<0.14 - <0.02
	3	14	0	0	0.9	1.1 - 0.8	0.5 - 0.3	<0.17 - <0.09
	4	14	0	0	0.9	1.2 - 0.6	0.6 - 0.3	<0.17 - <0.07
1992	1	14	0	0	0.9	1.1 - 0.7	0.5 - 0.3	<0.16 - <0.10
	2	14	0	0	1.0	1.1 - 0.7	0.5 - 0.2	<0.14 - <0.04
	3	14	0	0	0.9	1.3 - 0.8	0.6 - 0.2	<0.16 - <0.07
	4	14	0	0	0.9	1.1 - 0.7	0.5 - 0.3	<0.17 - <0.10
1993	1	14	0	0	1.0	1.3 - 0.8	0.6 - 0.3	<0.12 - <0.03
	2	14	0	0	1.0	1.5 - 0.7	0.6 - 0.3	<0.17 - <0.06
	3	14	0	0	0.9	1.3 - 0.6	0.5 - 0.3	<0.16 - <0.09
	4	14	0	0	0.8	1.0 - 0.6	0.5 - 0.2	<0.13 - <0.07
1994	1	14	0	0	0.9	1.2 - 0.7	0.5 - 0.3	<0.11 - <0.03
	2	14	0	0	1.0	1.3 - 0.8	0.5 - 0.3	<0.17 - <0.03
	3	14	0	0	0.9	1.3 - 0.7	0.6 - 0.3	<0.17 - <0.08
	4	14	0	0	1.0	1.4 - 0.8	0.6 - 0.3	<0.12 - <0.07
1995	1	14	0	0	1.0	1.2 - 0.7	0.5 - 0.3	<0.15 - <0.05
	2	14	0	0	0.9	1.3 - 0.8	0.6 - 0.3	<0.14 - <0.03

Notes:

(a) Values preceded by "<" symbols are the minimum detectable levels (cobalt-60 energy range) and statistically computed upper limits of activity (specific cobalt-60), which are expressed at the 90% confidence level for that particular analysis. Sample analysis results were less than these values, which varied from sample to sample and location to location due to statistical fluctuations. No cobalt-60 was present in any sample.

(b) Data not available.

Since 1973, approximately fourteen samples of harbor sediment were taken quarterly at Hunters Point Annex and analyzed by MINS. Sampling locations are shown on Figure 6.1. Sample locations are selected based on berthing locations of nuclear-powered ships and at points upstream and downstream of berths where tidal ebb and flood currents could deposit suspended radioactivity.

A modified six-inch square Birge-Ekman dredge is used to obtain a sample of the top half-inch to one-inch of the bottom sediment. This depth was selected since surficial sediments are more mobile and more accessible to marine life.

Sediment samples are drained during collection to remove liquid before shipyard analysis. Since nearly all liquid is removed, the samples show the consistency of thick mud, and their analytical results are reported in pCi/g.

Prior to 1978, sediment samples were collected in one-quart cylindrical containers and analyzed using a sodium iodide scintillation detector in conjunction with a 512-channel analyzer. In addition to gross gamma activity, a limited range of the gamma spectrum which would include cobalt-60 ("cobalt-60 energy range") was measured. In 1978, a high-resolution spectroscopy system consisting of a 4096-channel analyzer and germanium detector was put into service, and actual cobalt-60 activities have been measured since then, in addition to gross gamma and cobalt-60 energy range. Collected sample material is placed in Marinelli containers to provide consistent counting geometry.

Sample analysis is conducted using a standardized analysis procedure which has been approved by the NNPP. All Program Fleet and shore-based activities conducting environmental monitoring utilize this method.

MINS utilized crosschecks by an independent Department of Energy (DOE) laboratory to verify sample analysis results. A portion of the first quarter sediment samples were re-analyzed by the DOE laboratory. For this analysis, a higher efficiency, larger volume detector and very long counting times are used, to achieve the superior minimum sensitivity needed to detect extremely low concentrations of radionuclides. Results for the re-analyzed sediment samples are presented in Table 6-2. In addition, since 1980, a test sample having a known quantity of cobalt-60 radioactivity was sent to MINS by the laboratory annually for analysis. MINS was not provided with quantitative data beforehand. Analysis results were forwarded to the DOE laboratory for comparison with DOE counting results and the activity known during sample preparation. MINS results were consistent with DOE laboratory results. Tables 6-3 and 6-4 provide side-by-side comparisons of shipyard data and DOE laboratory data for routine samples, and for the DOE laboratory test samples, respectively.

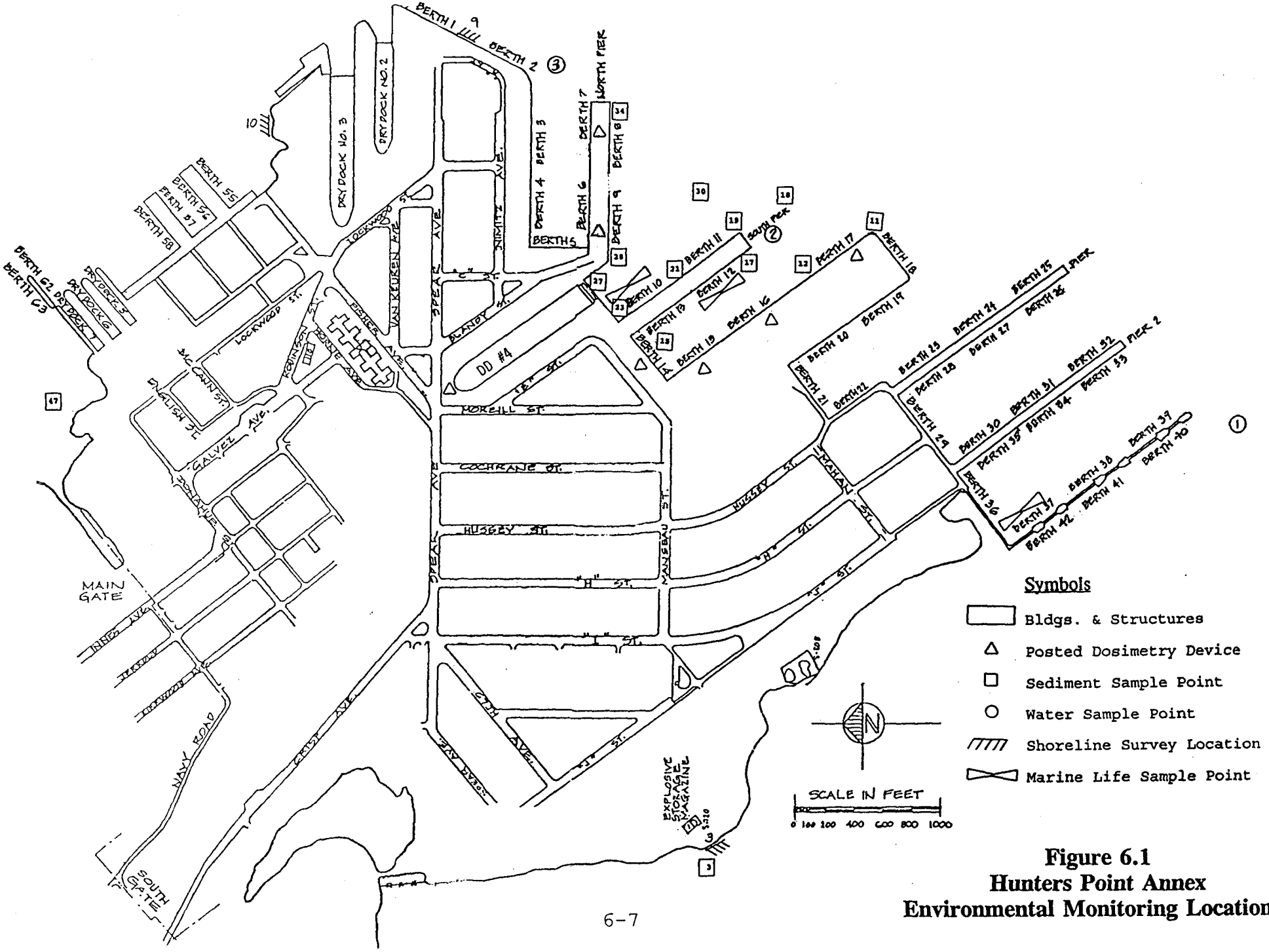


Figure 6.1
Hunters Point Annex
Environmental Monitoring Locations

Table 6-2
Sediment Enhanced Monitoring Results
Hunters Point Annex
1978-1994

Year	Specific Cobalt-60 Activity (pCi/g)		
	Location Number (a)		
	3	19	47
1994	<0.007	<0.007	<0.007
1993	<0.008	<0.007	<0.009
1992	<0.006	<0.006	<0.007
1991	<0.008	<0.006	<0.006
1990	<0.014	<0.013	<0.014
1989	<0.019	<0.027	<0.025
1988	<0.026	<0.029	<0.025
1987	<0.025	<0.032	<0.034
1986	(b)	(b)	(b)
1985	(b)	(b)	(b)
1984	<0.031	(b)	(b)
1983	(b)	(b)	<0.013
1982	<0.019	<0.014	<0.010
1981	<0.013	<0.018	<0.009
1980	<0.010	<0.011	<0.015
1979	<0.008	(b)	<0.018
1978	<0.011	(b)	<0.010

Additional data for Table 6-2 (pCi/g):

1986: No. 15, <0.024; No. 27, <0.025; No.28, <0.025
1985: No. 15, <0.020; No. 17, <0.024; No.23, <0.021
1984: No. 15, <0.026; No. 17, <0.027; No.23, <0.025
1983: No. 17, <0.010; No. 27, <0.011; No.28, <0.010
1978: No. 27, <0.014

Notes for Table 6-2:

"<" Indicates the minimum detectable activity for this analysis.
(a) Locations are identified on Figure 6.1.
(b) No enhanced analysis.

Table 6-3
Comparison of Shipyard and DOE Laboratory Data for Routine Sediment Samples (pCi/g)
Hunters Point Annex

(KAPL = Knolls Atomic Power Laboratory)

Gross Gamma (0.1 - 2.1 Mev)							
		Average		Range			
				Shipyard		KAPL	
Year	No. of Samples	MINS	KAPL	High	Low	High	Low
1995	3	1.10	1.05	1.16	1.02	1.08	1.04
1994	3	1.05	1.08	1.21	0.90	1.21	0.94
1993	3	1.09	1.08	1.25	0.95	1.24	0.89
1992	3	1.00	0.99	1.16	0.87	1.11	0.86
1991	3	1.05	1.01	1.30	0.87	1.20	0.85
1990	3	0.91	0.93	1.05	0.82	1.03	0.88
1989	3	1.08	0.94	1.18	1.02	1.00	0.84
1988	3	1.0	1.01	1.2	0.9	1.23	0.88
1987	3	0.9	0.95	1.0	0.8	1.09	0.83
1986	3	0.83	0.77	0.98	0.75	0.92	0.60
1985	3	0.74	0.77	0.80	0.67	0.84	0.67
1984	4	0.84	0.84	1.00	0.78	0.98	0.78
1983	4	0.85	0.75	0.88	0.82	0.78	0.72
1982	3	0.85	0.81	0.90	0.80	0.82	0.79
1981	3	0.9	0.98	1.0	0.8	1.05	0.85
1980	3	1.0	0.89	1.1	0.9	0.96	0.83
1979	3	1.1	1.04	1.1	1.1	1.05	1.04
1978	3	0.9	0.84	1.0	0.8	0.91	0.80

Cobalt-60 Energy Range (1.1 - 1.4 MeV)						
	Average		Range			
			Shipyard		KAPL	
Year	MINS	KAPL	High	Low	High	Low
1995	0.44	0.37	0.45	0.41	0.38	0.35
1994	0.45	0.42	0.54	0.41	0.48	0.38
1993	0.43	0.37	0.45	0.42	0.44	0.31
1992	0.45	0.41	0.46	0.44	0.45	0.37
1991	0.43	0.41	0.53	0.37	0.52	0.35
1990	0.36	0.37	0.38	0.32	0.40	0.31
1989	0.46	0.33	0.51	0.40	0.35	0.31
1988	0.4	0.41	0.5	0.4	0.49	0.35
1987	0.4	0.41	0.4	0.4	0.54	0.35
1986	0.43	0.33	0.56	0.31	0.38	0.29
1985	0.34	0.32	0.37	0.26	0.44	0.27
1984	0.37	0.41	0.46	0.29	0.53	0.34
1983	0.35	0.33	0.38	0.33	0.34	0.31
1982	0.36	0.35	0.37	0.35	0.38	0.32
1981	0.5	0.42	0.5	0.5	0.50	0.34
1980	0.5	0.35	0.5	0.4	0.38	0.32
1979	0.4	0.41	0.4	0.4	0.43	0.39
1978	0.4	0.34	0.4	0.3	0.40	0.29

Table 6-3 (continued)
Comparison of Shipyard and DOE Laboratory Data for Routine Sediment Samples (pCi/g)
Hunters Point Annex

(KAPL = Knolls Atomic Power Laboratory)

Specific Cobalt-60 Photopeak						
	Average		Range			
			MINS		KAPL	
Year	MINS	KAPL	High	Low	High	Low
1995	0.12	0.042	0.12	0.12	0.043	0.039
1994	0.09	0.089	0.11	0.08	0.105	0.074
1993	0.11	0.047	0.16	0.06	0.054	0.042
1992	0.1	0.085	0.1	0.1	0.105	0.064
1991	0.1	0.093	0.1	0.1	0.126	0.062
1990	0.1	0.076	0.1	0.1	0.087	0.056
1989	0.10	0.048	0.12	0.07	0.051	0.044
1988	0.1	0.069	0.1	0.1	0.085	0.052
1987	0.1	0.075	0.1	0.1	0.078	0.071
1986	0.08	0.052	0.09	0.06	0.071	0.033
1985	0.04	0.078	0.06	0.03	0.093	0.059
1984	0.08	0.084	0.10	0.04	0.120	0.051
1983	0.08	0.064	0.10	0.05	0.089	0.043
1982	0.09	0.055	0.12	0.07	0.081	0.037
1981	0.1	0.097	0.1	0.1	0.124	0.071
1980	0.1	0.061	0.1	0.1	0.095	0.035
1979	0.1	0.066	0.1	0.1	0.071	0.060
1978	0.1	0.069	0.1	0.1	0.097	0.037

Note: The values for the cobalt-60 photopeaks are the minimum detectable activity (MDA). Actual results were below MDA.

Table 6-4
Comparison of Shipyard and DOE Laboratory Data for Test Samples

Simulated Sediment (pCi/g)												
	Actual Concentration		Shipyard Measured (a)		Actual Concentration		Shipyard Measured (a)		Other Radionuclides			
									Actual Concentration		Shipyard Measured (a)	
Year	Co-60 Activity	+/-	Co-60 Activity	+/-	Cs-137 Activity	+/-	Cs-137 Activity	+/-	Radionuclide	Activity	+/-	Activity	+/-
1995	1.12	0.06	1.16	0.09	1.18	0.06	1.22	0.08	---	---	---	---	---
1994	1.21	0.06	1.12	0.34	1.29	0.06	1.25	0.26	---	---	---	---	---
1993	2.00	0.06	2.00	0.17	2.00	0.08	2.14	0.16	---	---	---	---	---
1992	1.05	0.03	0.97	0.09	1.15	0.05	1.07	0.08	---	---	---	---	---
1991	1.10	0.03	1.09	0.09	1.10	0.05	1.08	0.08	---	---	---	---	---
1990	1.12	0.03	1.11	0.10	1.06	0.04	1.12	0.08	---	---	---	---	---
1989	1.09	0.03	1.20	0.28	1.36	0.05	1.41	0.23	---	---	---	---	---
1988	1.05	0.03	1.17	0.32	1.11	0.05	1.39	0.26	Co-57	0.49	0.01	0.53	0.07
1987	0.90	0.03	0.82	0.22	0.85	0.03	0.99	0.21	---	---	---	---	---
1986	1.14	0.03	1.18	0.28	0.87	0.03	0.90	0.20	Cr-51	9.38	0.24	7.4	4.1
1985	2.16	0.06	2.23	0.35	0.60	0.02	0.70	0.19	Co-57	0.47	0.01	0.50	0.08
1984	1.97	0.05	2.00	0.34	0.92	0.03	0.92	0.21	Co-57	0.59	0.02	0.58	0.10
1983	0.70	0.02	0.69	0.19	1.56	0.06	1.65	0.23	Cs-134	1.44	0.04	1.50	0.27
1982	1.28	0.03	1.46	0.28	0.80	0.03	0.91	0.19	Cr-51	3.46	0.09	3.15	1.84
1981	1.11	0.03	1.05	0.23	1.64	0.06	1.67	0.27	Mn-54	1.33	0.03	1.38	0.25
1980	1.11	0.22	1.2	0.24	1.12	0.22	0.8	0.24	Co-57	1.94	0.16	1.9	0.12

Notes: (a) The error term (+/-) is given as 2 sigma counting error.
(b) Other radionuclides were not present in test samples in 1987 and 1989-1995.

Table 6-4 (continued)
Comparison of Shipyard and DOE Laboratory Data for Test Samples

Simulated Air Filter (pCi) (a)				
	Actual Activity Co-60		Shipyard Measured (b) Co-60	
Year	Activity	+/-	Activity	+/-
1995	209	7	204	15
1994	207	7	173	35
1993	391	11	378	29
1992	191	6	176	46
1991	202	6	201	9
1990	199	5	209	16
1989	191	5	164	37
1988	218	6	268	48
1987	150	4	144	18
1986	170	4	164	5
1985	255	7	244	7
1984	296	8	285	46
1983	210	5	221	42
1982	142	4	146	35
1981	267	7	273	50
1980	184	5	160	4

Notes:

(a) The simulated "air filters" are quality assurance samples. They have not been used as air filters but were spiked with the identified radionuclides to test shipyard analytical procedures and equipment. Therefore, results are expressed as total activity rather than concentration.
(b) The error term (+/-) is given as 2 sigma counting error.

Prior to 1978, the DOE laboratory also periodically performed limited cobalt-60 energy range measurements using the older analysis equipment. Results were consistent between MINS and the DOE laboratory, and showed no increase in radioactivity above normal background levels.

In 1975 and 1983, MINS issued an "Assessment of Environmental Radiation Effects Resulting from Operations Associated with Nuclear Propulsion Plant Work at Mare Island Naval Shipyard," References 18 and 19. These assessments also included Hunters Point Annex. Both of these assessments concluded that the Navy has kept exposure to the general public and effluent to unrestricted areas below detectable levels and indistinguishable from natural background. Reference 18 used methods based on the requirements of Reference 20; these methods are used by the commercial nuclear industry in performing population dose estimate calculations for light water reactors.

In 1988 (data reported in 1989) the U.S. Environmental Protection Agency (EPA) conducted a radiological survey of San Francisco Bay. The results of this survey were published in Reference 21. The 1988 EPA survey concluded:

> "Only radionuclides of natural origin and trace amounts of Cs-137 from previous nuclear weapons testing were detected in the harbor sediment samples. No radioactivity associated with the operation and maintenance of nuclear-powered warships was detected in any of either the dredge or core sediment samples.
>
> "No tritium or gamma-ray emitters, other than trace amounts of those occurring naturally, were detected in surface water from the harbors or in nearby drinking supplies.
>
> "No gamma-ray emitters, other than trace amounts of those occurring naturally, were detected in harbor algae, mussels, or sea lettuce.
>
> "Gamma-ray surveys of the harbors failed to detect any exposure rates elevated significantly above background.
>
> "Based on this survey, operations related to nuclear-powered warship activities have contributed no detectable radioactivity to the harbors at Mare Island, Alameda, and Hunters Point. Thus, under present conditions Naval operations within these harbors pose no radiological health problem to the public."

No monitoring by the State of California has been performed.

The data collected by MINS and the EPA during the period 1966 through the second quarter of 1995 clearly support the conclusion that any trace (though undetected) levels of residual cobalt-60 that may be present in harbor sediment: a) contribute a negligible increase to background radioactivity levels; and b) pose no hazard to the public, either directly or via the food chain, and pose no hazard to the ecological systems of the region.

6.1.2 **Harbor Water Monitoring**

Reference 18 indicates that water sampling was performed each quarter since 1966 at Hunters Point Annex. The most recent sampling locations are shown on Figure 6.1.

Sample locations are selected based on areas where radioactive liquids could have been discharged and at other appropriate harbor locations.

Beginning in 1966, a sodium iodide scintillation detector was used to count one-liter samples in polyethylene bottles. A 512-channel analyzer was used to measure gross gamma activity in terms of cobalt-60 equivalent, and cobalt-60 energy range activity. Since 1978, a 4096-channel multichannel analyzer and germanium high resolution spectroscopy system has been used, and actual cobalt-60 activity has been determined. Like sediment samples, a Marinelli container is used for water sample analysis.

The counting procedure for water samples is the same as for sediment samples. The quality control sample sent annually by the DOE laboratory serves to verify both sediment and water sample analysis results.

Water samples were collected near the entrance to Drydock 4 and in waters near the north shore of HPA by the EPA in 1988. Reference 21 reports that no cobalt-60 was detected in any water sample taken during these surveys. A review of both shipyard gamma counting results and the series of environmental monitoring reports published annually by the NNPP reveals that no cobalt-60 has ever been detected in harbor water samples. Quarterly data for each year was reported annually by MINS. The water sample data are not tabulated in this report since they reflect nearly 30 years of less than minimum detectable activity values.

The conclusions reached by the Navy in its annual reports are confirmed by Reference 21. The Reference 21 conclusions are quoted in Section 6.1.1.

6.1.3 **Marine Life Sampling**

Marine life samples were collected at HPA as early as 1977. One sample each of marine plant, mollusk, and crustacean were collected and analyzed for gross gamma radioactivity and radionuclide content with a gamma scintillation spectrometer. The following species of marine life were collected and analyzed:

Species	Common Name
Cancer productus	Rock crab
Porphyra perforata	Sea lettuce
Mytilus californianus	California sea mussel

No cobalt-60 was detected in any sample.

Beginning in 1977, Program activities conducting environmental monitoring were required to obtain marine life samples during July of each year. Samples include available species of marine plants, mollusks, and crustaceans from locations in the vicinity of the shipyard where nuclear-powered ships berth. Analysis data of marine life samples taken since 1977 are shown in Table 6-5.

Table 6-5
Marine Life Monitoring Results
Hunters Point Annex
1977-1994

Year	Specific Cobalt-60 Activity (pCi/g) (a)		
	Mollusk	Crustacean	Seaweed
1994	<0.006 & <0.006	<0.006 & <0.007	<0.007 & <0.007
1993	<0.005 & <0.006	<0.006	<0.008 & <0.009
1992	<0.005 & <0.006	<0.006 & <0.006	<0.007 & <0.008
1991	<0.007 & <0.007	<0.007 & <0.007	<0.007 & <0.008
1990	<0.011 & <0.012	<0.010 & <0.011	<0.012 & <0.013
1989	<0.021 & <0.026	<0.019 & <0.024	<0.014 & <0.015
1988	<0.023 & <0.024	<0.018 & <0.022	<0.026 & <0.027
1987	<0.021 & <0.022	<0.018 & <0.020	<0.022 & <0.023
1986	<0.024	<0.020	<0.025
1985	<0.017	<0.016	<0.023
1984	<0.023	<0.023	<0.028
1983	(b)	(b)	<0.009
1982	<0.006	<0.011	<0.012
1981	<0.004	<0.010	<0.014
1980	(c)	(c)	(c)
1979	<0.007	<0.010	<0.010
1978	<0.007	<0.008	<0.008
1977	<0.1	<0.1	<0.1

Notes:

(a) Values for 1977 are for cobalt-60 energy range gamma, vice specific cobalt-60. Values preceded by "<" symbols are the minimum detectable levels, which are expressed at the 90% confidence level. All data is from the more sensitive DOE laboratory analyses, rather than from shipyard analyses.
(b) Seaweed was the only marine life sampled during the year.
(c) Data is not available. However, Mare Island Naval Shipyard reported that marine life samples taken near nuclear-powered ship berthing areas at Hunters Point in 1980 showed no indication of non-naturally occurring radionuclides attributable to NNPP operations.

As a quality control, all marine life samples have been sent annually since 1977 to a DOE laboratory for independent analysis. Results of shipyard analyses have been consistent with the DOE laboratory results. Table 6-6 provides side-by-side comparisons of shipyard data and DOE laboratory data for marine life samples since 1988, when shipyard data began being reported separately for HPA.

Table 6-6
Comparison of Shipyard and DOE Laboratory Data for Marine Life Samples (pCi/g)
Hunters Point Annex

(KAPL: Knolls Atomic Power Laboratory)

Specific Cobalt-60 Photopeak (a)							
		Average		Range (b)			
				MINS (b)		KAPL	
Year	No. of Samples	MINS	KAPL	High	Low	High	Low
1994	6	0.09	0.007	0.13	0.05	0.007	0.006
1993	5	0.06	0.007	0.09	0.05	0.009	0.005
1992	6	0.07	0.006	0.14	0.01	0.008	0.005
1991	6	0.11	0.007	0.15	0.08	0.008	0.007
1990	6	0.07	0.012	0.08	0.05	0.013	0.010
1989	6	0.07	0.020	0.07	0.06	0.026	0.014
1988	6	0.20	0.023	0.41	0.05	0.027	0.018

Notes:

(a) All entries are MDA values; no cobalt-60 was detected in any sample.
(b) MINS reported averages for each type of sample (i.e., mollusk, crustacean, and marine plants). Range values through 1995 are therefore ranges of these averages.

During the 1988 EPA survey, sea lettuce and mussels were collected from the harbor. Reference 21 reports that only small quantities of naturally occurring radionuclides, principally potassium-40, and cesium-137 typical of fallout from previous nuclear weapons testing, were measured in the sea lettuce sample. The mussel sample contained only potassium-40 (10 pCi/g dry) and a trace of cesium-137 (0.02 pCi/g dry). "Thus, no radioactivity indicative of nuclear-powered ships was detected in any of the biological samples that were collected from the harbors."

On the basis of the data shown in Table 6-5 and the findings of the EPA, there has been no accumulation of cobalt-60 in marine organisms as a result of the operation of nuclear-powered ships or work on those ships at Hunters Point Annex.

6.1.4 **Core Sampling**

Core sampling was performed by the Environmental Protection Agency during their 1988 survey, Reference 21. The sample was taken near the entrance to Drydock 4 to determine whether radioactivity may have accumulated below the top layer of sediment, which was sampled on a routine basis.

The core was obtained with a 3.8 centimeter diameter by 61 centimeter plastic tube driven into the sediment by a mechanical driver. The core was frozen, cut in sections, freeze dried, and counted on an intrinsic germanium detector. The minimum detectable activity for cobalt-60 in this geometry is 0.1 pCi/g.

The Environmental Protection Agency results are presented in Reference 21. The sample was less than 0.1 pCi/g. The sampling results were included in the Reference 21 conclusions, which are quoted in Section 6.1.1.

6.2 **Dredging Records**

Maintenance dredging was periodically conducted at Hunters Point Annex to maintain the prescribed depth in waters surrounding the site.

Reference 1 reports that bay dredge materials were disposed of in the industrial landfill, located near the western boundary of HPA, between 1958 and 1974. Dredging records from Naval Facilities Engineering Command indicate that dredge spoils from HPA were disposed of in the ocean or at Alcatraz Island (EPA disposal site SF-11) between 1972 and 1989.

Table 6-7 presents a summary of information regarding dredging operations in Hunters Point Annex since 1970.

Remediation action is currently underway at the Industrial Landfill to identify radioactivity associated with operations of the National Radiological Defense Laboratory (NRDL). Although radium, possibly from buried radium-containing instruments, has been detected at this site, no radionuclides associated with the Naval Nuclear Propulsion Program have been found.

Table 6-7
Dredging Conducted
at Hunters Point Annex
1970-1989 (a)

Year	Contractor/Method	Dredging Location(s)	Disposal Site	Volume Cubic Yards
1989	Navy; Natco/Clamshell	Drydock 4 entrance	SF-11	107,000
1986	Triple A; Smith-Rice Co./Clamshell	Berths 3, 4, 6, and 7; Pier 2; Drydock 4 entrance	SF-11	180,000
1985	Triple A/Clamshell	Berths 3 and 4; Drydock 4 entrance	SF-11	250,000
1984	NA	Drydocks 2, 3, and 4 entrance	NA	24,000
1983	Triple A/Clamshell	Berths 8 and 9; Drydock 4 entrance	SF-11	293,000
1981	NA	Drydocks 2 and 4 entrance	NA	18,000
1980	NA	Drydocks 2, 3, 5, 6, and 7 entrance	NA	750
1974	NA	NA	NA	NA
1973	Navy/Clamshell	NA	Ocean	170,000
1972	Navy/Clamshell	Berths 8-12, 15, 16, 55, and 58; Drydock 4 entrance	Ocean	130,450
1971	NA	NA	NA	NA
1970	NA	Berths 1-7, 12, 16, 17, 22, and 23	NA	NA

Notes: (a) No dredging reported at Hunters Point since 1989.
NA = Information not available.
SF-11 = Site on Alcatraz Island.

6.3 **Perimeter Radiation Records**

Beginning in 1966, beta-gamma film badges were posted outside of controlled radiation areas to ensure that unmonitored personnel within the shipyard and the general public were not exposed to radiation levels above natural background.

In March 1969, the regulations were revised to expand film badge monitoring of the shipyard, to provide additional data that no member of the general public living or working outside the shipyard exceeded the radiation exposure they would receive due to natural background, even if they lived or worked immediately adjacent to the shipyard 24 hours per day.

From the second quarter of 1974 through the second quarter of 1975, film badges and thermoluminescent dosimeters (TLDs) were posted in the same locations to evaluate the use of TLDs in the environmental monitoring program. For the third quarter of 1975 and all subsequent quarters, TLDs only have been used at HPA. Figure 6.1 shows the locations of posted perimeter TLDs. Reference 18 provides an extensive discussion of the TLD perimeter radiation monitoring program.

Beginning in 1978, clusters of five TLDs were posted at background locations, replacing the single TLDs posted previously. Examples of background locations are residential fences in areas of Vallejo and Napa, California. This method provided a better statistical basis for background determination and improved reliability of the resulting data. Additionally, a special cluster of TLDs was posted on a pier adjacent to a shoreline area on Mare Island to permit comparison with the lower natural radioactivity of water as opposed to paving, concrete, and masonry structures typical at HPA. Background locations are shown on Figure 6.2.

Results of perimeter radiation monitoring are reported quarterly to the Naval Nuclear Propulsion Program. Table 6-8 lists the quarterly results of the HPA perimeter monitoring program since the second quarter of 1974, when the use of TLDs was initiated. The results of the monitoring verify that radiation exposure to the general public in occupied areas surrounding the base is indistinguishable from natural background.

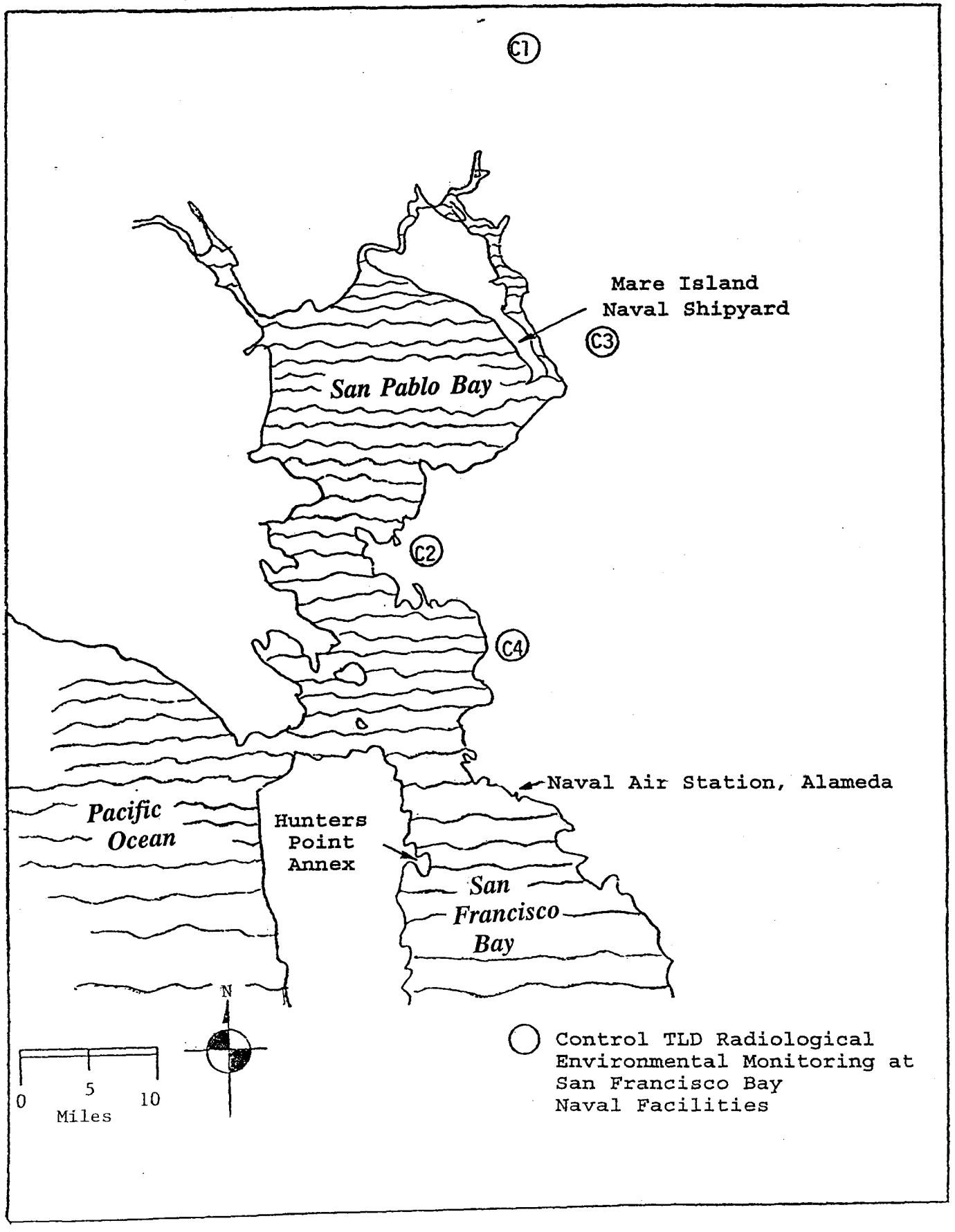


Figure 6.2
Environmental Radiation Background Locations

Table 6-8
Perimeter Radiation Monitoring
Hunters Point Annex
1974-1995

Year	Quarter	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
		Background	Perimeter	Background	Perimeter
1995	2	12.6-20.3	15.5-19.3	16.6	17.4
	1	14.0-22.0	16.9-18.8	17.2	17.8
1994	4	12.0-22.9	16.1-19.4	16.7	17.4
	3	13.0-20.9	14.8-18.2	16.8	16.7
	2	11.1-21.2	14.9-18.9	16.5	17.3
	1	13.4-22.5	15.9-20.4	17.4	17.9
1993	4	11.0-22.4	14.8-17.7	18.2	16.7
	3	13.5-22.6	12.8-19.1	18.0	17.2
	2	10.7-22.2	14.2-17.2	17.1	16.1
	1	13.2-21.9	15.5-18.1	17.4	17.0
1992	4	13.1-22.6	15.1-19.3	18.2	16.9
	3	12.6-22.2	15.4-18.3	17.8	17.2
	2	12.5-22.1	16.3-19.3	18.0	17.7
	1	12.7-22.2	16.0-18.9	17.2	17.1
1991	4	12.4-20.2	15.0-17.3	17.1	16.1
	3	12.1-23.2	15.5-18.1	17.4	17.4
	2	12.8-21.4	15.1-17.7	17.2	16.6
	1	12.9-21.7	16.1-18.4	17.3	17.3
1990	4	17.1-22.4	17.9-19.9	19.7	19.2
	3	9.6-22.5	15.3-18.6	17.7	16.9
	2	14.7-23.7	16.0-18.6	18.3	17.6
	1	10.1-21.6	14.8-18.9	18.0	17.0
1989	4	16.8-22.1	15.8-18.8	19.1	17.7
	3	15.8-21.0	16.1-20.1	18.2	18.3
	2	17.0-21.3	16.6-21.6	19.0	19.1
	1	18.0-20.9	20.2-22.1	19.2	21.2
1988	4	14.0-22.8	16.5-20.9	19.4	18.5
	3	11.4-20.8	15.6-17.8	18.0	16.6
	2	12.6-20.8	18.1-19.7	18.3	19.0
	1	12.6-20.8	17.8-21.1	18.8	19.8
1987	4	15.0-19.7	14.1-18.6	17.2	16.4
	3	16.0-23.0	19.9-22.2	19.5	21.0
	2	13.5-21.5	16.4-20.8	17.3	18.6
	1	14.2-22.7	15.8-19.0	16.3	17.8
1986	4	16.7-24.3	17.9-26.4	19.7	22.1
	3	16.3-20.2	17.5-19.5	17.4	18.7
	2	13.2-21.5	17.0-27.9	18.3	20.0
	1	18.0-25.4	21.2-25.7	21.4	23.7
1985	4	16.1-22.4	16.5-20.5	19.1	18.2
	3	16.1-20.9	16.7-20.1	18.8	18.0
	2	16.0-22.7	16.8-19.9	18.8	18.1
	1	14.9-20.5	17.4-21.1	17.3	19.0

Table 6-8 (continued)
Perimeter Radiation Monitoring
Hunters Point Annex
1974-1995

Year	Quarter	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
		Background	Perimeter	Background	Perimeter
1984	4	16.8-21.3	17.0-21.0	17.5	19.7
	3	16.2-21.2	(a)	18.5	(a)
	2	17.1-20.2	16.2-18.8	18.5	17.7
	1	16.2-20.3	16.6-18.7	17.5	17.4
1983	4	17.0-20.6	(a)	18.3	(a)
	3	16.7-21.3	14.1-16.6	18.8	15.0
	2	14.3-18.5	16.7-18.4	16.4	17.9
	1	15.2-22.5	17.3-18.8	19.3	17.9
1982	4	16.1-22.4	16.3-19.0	17.1	18.0
	3	18.0-25.4	16.4-18.4	17.4	17.4
	2	17.0-21.3	15.3-17.0	17.2	16.2
	1	14.7-23.7	(a)	18.0	(a)
1981	4	15.6-20.0	16.9-18.2	17.8	17.8
	3	14.5-18.9	16.1-18.3	18.8	17.6
	2	14.3-18.5	14.6-17.0	16.4	16.1
	1	17.0-21.6	18.1-19.8	19.3	18.9
1980	4	16.7-20.3	16.6-18.8	17.9	17.4
	3	16.5-21.3	16.5-18.5	18.9	17.6
	2	16.7-20.7	15.2-17.9	18.7	17.0
	1	16.7-22.3	16.0-19.1	19.5	18.2
1979	4	18.0-21.4	15.9-18.2	19.7	17.1
	3	15.2-22.5	16.7-19.7	18.5	18.4
	2	16.0-21.6	15.3-17.8	18.8	16.3
	1	16.5-21.1	17.6-19.8	18.8	18.7
1978	4	15.0-20.0	14.2-16.0	17.5	14.9
	3	18.6-26.2	17.2-22.6	22.5	19.4
	2	14.2-20.6	14.6-16.3	17.7	15.3
	1	13.6-19.6	14.0-16.8	16.6	15.0
1977	4	15.8-21.6	15.4-18.5	18.7	17.2
	3	16.7-22.7	16.5-19.0	19.7	17.9
	2	16.8-22.4	16.6-19.8	19.6	18.1
	1	17.1-21.5	16.4-19.5	19.3	18.0
1976	4	19.9-21.5	16.2-19.0	18.7	17.6
	3	16.0-21.0	15.4-27.8	18.5	18.1
	2	15.1-20.9	14.1-16.4	18.0	15.5
	1	15.9-20.1	14.1-19.6	18.0	16.2
1975	4	15.2-20.0	15.9-17.5	17.6	16.7
	3	16.3-23.0	16.5-18.0	19.3	17.3
	2	15.4-19.8	14.1-17.8	17.6	16.1
	1	15.8-19.8	14.1-16.6	17.8	15.6
1974	4	15.2-20.4	13.0-16.7	17.8	14.7
	3	17.9-22.8	16.4-20.0	20.5	17.8
	2	18.5-25.8	17.0-20.9	21.0	18.8

(a) Data not available.

Table A-1 of Reference 22 lists the annual total body dose due to natural sources in the vicinity of HPA as approximately 63 mrem (7.2 μR/hr): 28 mrem is due to terrestrial sources of natural radioactivity and 35 mrem is due to cosmic radiation. Reference 22 is cited extensively by the National Council on Radiation Protection and Measurements (NCRP) as a continuing source of data for natural background radiation exposure estimates. This referenced estimate for natural background radiation exposure rate in the vicinity of HPA is consistent with data in Table 6-9 for the vicinity of HPA, which is a tabulation of values reported in References 18 and 21, along with the randomly selected third quarter data for 1986. (The results of monitoring using TLDs are reported in Table 4A of Reference 18. Reference 21 reports the results of the Environmental Protection Agency survey. Table 3 of Reference 21 reports the range of gamma-ray exposure rates as compared to an average background of 4.1 μR/hr.)

Table 6-9
Perimeter Radiation Monitoring Comparison
Hunters Point Annex

Year	Survey	Ref.	Exposure Rate Range μR/hr	Average Exposure Rate μR/hr
1986 3rd Qtr.	Shipyard Quarterly Monitoring Data	N/A		
	Background		7.5 - 9.2	8.0
	Perimeter		8.0 - 8.9	8.6
1989	U.S. EPA Radiological Survey	21	3.6 - 5.0	4.4
1974	Shipyard Assessment of Environmental Radioactivity	18		
	Background		Not reported	9.0
	Perimeter		7.1 - 8.8	7.9

N/A = Not applicable.

EPA concluded in Reference 21 that "gamma-ray surveys of the harbors failed to detect any exposure rates elevated significantly above background." This conclusion is consistent with the Navy findings reported annually for the past 30 years in Reference 14 and successive reports through Reference 10.

6.4 **Shoreline Monitoring Records**

The Navy has conducted gamma radiation surveys of selected shore areas uncovered at low tide since 1966. The purpose of this monitoring is to determine if any radioactivity has washed ashore. These surveys are conducted during the second and fourth quarters of the year. Areas are selected based on the likelihood of suspended radioactivity being deposited by tidal currents near nuclear ship berthing areas. Two or more background readings are taken at least thirty feet from the high water line at each survey location.

Table 6-10 summarizes the results of these surveys since 1972. These surveys were performed using a PRM-5N/SPA-3 gamma scintillation survey meter. This instrument is calibrated to permit distinguishing between natural and non-naturally occurring radioactivity; it is not calibrated for the direct conversion of count rate data to natural background radiation dose rates.

Shorelines selected for monitoring are shown on Figure 6.1. These areas were located on Federal property and were thus readily accessible for monitoring by Naval personnel.

The data of Table 6-10 show that there has been no measurable increase in radioactivity along monitored shorelines.

6.5 **Drydock Surveys**

Beginning in 1985, Drydock 4 was used intermittently to support dry-docking of nuclear powered surface combat ships. In April 1985, detailed radiological surveys were performed to establish background radiation levels at the drydock before its use. The drydock was used to support availabilities through 1989. After each availability, surveys were performed to confirm that the radiological condition of the drydock had not increased from the initial condition. Drydock surveys consisted of: (1) direct frisk surveys of all accessible surfaces, within one-half inch; (2) gamma scintillation surveys at waist level and within one-half inch of surfaces; (3) gross gamma activity analysis of soil and loose material; and (4) isotopic spectroscopic analysis of samples and selected areas of the drydock. Reference 15 presents details of surveys performed at Drydock 4 and their results.

The results of drydock surveys show that NNPP activities have had no measurable effect on normal background radiation levels.

Based on survey results, Drydock 4 was considered to be free of radioactive contamination and was released from the NNPP in 1994.

Table 6-10
Shoreline Radiation Monitoring
Hunters Point Annex
1972-1995

Year	Average Background Count Rate kcpm	Average Shoreline Count Rate kcpm	Shoreline Count Rate Range kcpm
1995 (a)	4.0	3.3	2.3 - 4.5
1994	3.8	3.3	2.0 - 4.8
1993	4.0	3.5	2.3 - 4.8
1992	3.6	3.3	2.0 - 4.8
1991	4.1	3.5	2.0 - 5.0
1990 (b)	3.0	2.8	2.0 - 3.8
1989	2.7	2.7	1.5 - 4.3
1988	4.1	3.7	1.5 - 5.0
1987	3.8	3.2	2.0 - 5.0
1986	(c)	(c)	(c)
1985	(c)	(c)	(c)
1984 (b)	3.8	3.9	3.0 - 4.5
1983	2.5	3.1	2.0 - 4.0
1982	4.9	3.7	2.3 - 5.0
1981	3.4	3.0	1.3 - 4.0
1980	3.4	3.2	2.5 - 4.3
1979	4.5	3.3	2.3 - 4.3
1978	5.5	3.7	3.0 - 5.0
1977	4.1	4.1	2.5 - 6.5
1976	4.4	3.7	2.5 - 5.3
1975	4.0	3.5	2.8 - 4.8
1974	4.3	4.2	3.1 - 5.7
1973 (b)	3.9 (d)	3.5 (d)	2.1 - 4.9 (d)
1972	0.2	0.2	0.1 - 0.5

Notes:

(a) Only first quarter monitoring was performed in 1995.
(b) Numerical data for entire year not available; data is from second or fourth quarter only. Summary of results reported no shoreline areas with levels above normal background.
(c) Data not available.
(d) The calibration procedure for the instrument used to perform shoreline radiation monitoring was adjusted in 1973 to reflect an energy range of 0.1 MeV to about 8 MeV, vice 0.6 MeV to about 8 MeV. Thus, the higher shoreline survey results since 1973 include lower energy radiation from natural radioactivity.

6.6 **Routine Radiological Surveys**

To ensure proper posting of radiation areas, gamma surveys were performed weekly in occupied radiological areas. Monthly surveys were performed on any potentially contaminated ducts, piping, or hoses in use. Surveys were performed quarterly in locked, unoccupied areas.

To ensure that no environmental release of contamination occurred, surveys for loose surface contamination were conducted either each shift, daily, or weekly, depending on the work site and potential for release.

Since active radiological work and storage areas were only located within Drydock 4, routine building searches for radioactive material and radiological surveys of berths were not performed at HPA.

7.0 **RESIDUAL RADIOACTIVITY**

Of all the environmental radioactivity data collected, analyzed, and reported by the Navy since 1966 and by the U.S. Environmental Protection Agency in 1989, no cobalt-60 or other radioactivity attributable to NNPP work at Hunters Point Annex has ever been detected.

8.0 **ASSESSMENT OF ENVIRONMENTAL IMPACT**

Reference 23, "Guidance for Performing Preliminary Assessments under CERCLA," lists four pathways of possible environmental transport, each evaluated by three elements. These pathways include ground water, surface water, soil exposure, and air. The elements are the likelihood of release (including the likelihood of a substance migrating through a specific pathway), the waste characteristics, and the targets.

The following sections evaluate the data and information presented in this report within the framework of Reference 23.

Reference 19 calculates the annual dose to individuals from pathways derived from the requirements of 10CFR50 (Reference 20), for Mare Island Naval Shipyard (MINS; a typical NNPP Naval shipyard); due to far greater workload, MINS would have had a higher potential radioactive source term than existed at Hunters Point Annex (HPA), and provides a conservative comparison. Elements of the 10CFR50 pathways are comparable to the air, soil exposure, and surface water pathways evaluated by the protocol of Reference 23. It is informative to compare the results of these assessments in order to quantify the potential exposures via the pathways considered in Reference 23.

8.1 **Ground Water Pathway**

The ground water pathway considers potential exposure threats to drinking water supplies via migration to and within aquifers.

As discussed in Section 3, radiological work at HPA was performed within Drydock 4 and aboard the ships being serviced in Drydock 4. Any inadvertent release of radioactivity from such operations would be expected to remain isolated aboard the ships or within the drydock, thereby isolating the soil zone from any potential release mechanisms discussed below. The former Controlled Industrial Area surrounding Drydock 4 is mostly covered with paving or structures that also isolate the soil zone from any potential release occurring outside the drydock. Without access to the soil, percolation into the aquifer cannot occur. That no radioactivity to infiltrate the aquifer exists above background levels is established in evaluating the soil exposure pathway in Section 8.3.

Although influenced by tidal conditions, water contained in the aquifer underlying HPA generally flows outward toward San Francisco Bay. There has been no identifiable release of NNPP radioactivity which could threaten the ground water in the vicinity of HPA. As reported in Section 3, no operational wells are within one mile of HPA, and all wells at HPA are monitoring wells.

8.1.1 **Release Mechanisms Affecting Ground Water**

Radioactivity being released to ground water is the least likely mechanism. This could conceivably occur as a result of a release to the soil, atmosphere, or surface water. The radioactivity, which is primarily in an insoluble particulate form, would have to infiltrate through the soil to the ground water. As discussed above and in Section 3, no drinking water supplies would be affected.

8.1.2 **Ground Water Targets**

Primary targets are defined as populations served by drinking water wells that are suspected to have been exposed to a hazardous substance. There has been no suspected NNPP radioactivity release from the site to ground water; thus, no primary targets are identified.

Secondary targets include populations served by all drinking water wells within four miles of the site that are not suspected to have been exposed to a hazardous substance. Reference 4 reports that ground water at HPA is not used for any purpose. No irrigation or water supply wells are located on the site. There are no known public supply wells within four miles of the site. A spring located upgradient and hydraulically distinct from the aquifer, approximately one mile northwest of HPA, is used for commercial bottled water.

There are no Wellhead Protection Areas within the region. Since ground water within the four-mile zone has uses other than drinking water, it would be considered a resource.

8.1.3 **Ground Water Pathway Assessment**

There has been no identifiable release of radioactivity which could threaten ground water in the vicinity of HPA and no mechanism by which a potential contaminant could be transported to target receptors.

8.2 **Surface Water Pathway**

The surface water pathway considers potential exposure threats to drinking water supplies, to human food chain organisms, and to sensitive environments.

San Francisco Bay is a salt water estuary that does not supply any of the drinking water needs of the region.

Analytical data collected by the Navy consisting of harbor water, biota, and sediment samples, along with data reported in 1989 by the Environmental Protection Agency, have not detected cobalt-60 in any water, marine biota, or sediment since sampling was begun.

There are no primary sensitive environments within the 15-mile tidal influence zone of concern. Secondary sensitive environments include wetlands along the shoreline. Wetland frontage is estimated at three to four miles. In addition, mudflats are located in India Basin to the north, and South Basin to the south. The mudflats occupy the intertidal zone exposed at low tide and provide habitat for numerous invertebrates which are prey to several species of shorebirds and fish. Wetlands and mudflats have been identified as rare or sensitive habitats at HPA. Figure 8.1 presents the locations of wetlands and mudflats at HPA.

8.2.1 **Release Mechanisms Affecting Surface Waters**

Air release mechanisms can disperse radioactivity to local surface waters, but the potential effect of low level discharges via the air pathway is very small. Of greater potential concern would be direct liquid and solid material discharges to surface water. Leaks or ruptures from drums used to collect radioactive liquid in Drydock 4 would be contained within the drydock.

8.2.2 **Surface Water Targets**

Surface water targets are sub-divided into drinking water, human food chain, and environmental. All of the fresh water for the public supply is obtained from areas far removed from HPA. The City and County of San Francisco supplies HPA with unblended water from the Hetch-Hetchy distribution system, which is replenished with waters from the Sierra Nevada Mountain Range, approximately 160 miles northeast of HPA.

There are no intakes within the target distance limit as defined in Reference 23. As a drinking water supply, there is no resource within the target distance limit.

The waters of HPA provide potential migration pathways of contaminants to the human population. Extensive fishing occurs in an area between two miles north and two miles south of HPA, and the bay is used for boating and wind surfing. Reference 2 reports: "Several edible fish species including striped bass, sturgeon, sand shark, herring, flounder, perch, and bullhead may be or become contaminated from [non-radioactive] sources on site."

Fishing and shellfishing occurs within the 15-mile target distance limit. This range includes areas in San Francisco Bay used for commercial fishing, recreational fishing, and fish nurseries. Since San Francisco Bay is an estuary and is influenced by tidal flow, the waters of HPA would be classified as coastal tidal water in accordance with 40CFR300, Table 4-13.

The 15-mile target distance limit includes the Pacific Ocean and the majority of San Francisco Bay. Table 8-1 lists all surface water bodies within the 15-mile tidal influence zone.

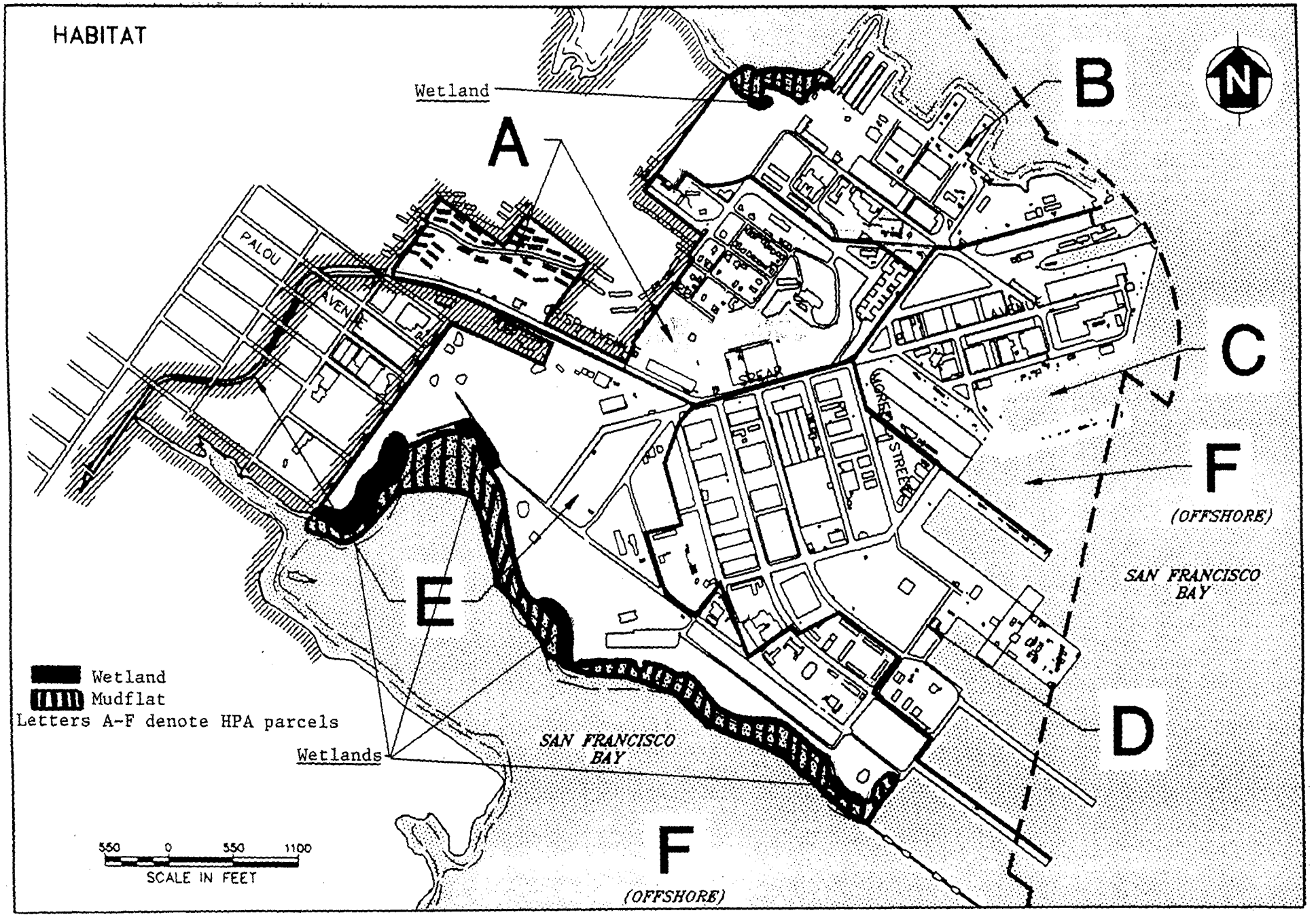


Figure 8.1
Wetlands and Mudflats at Hunters Point Annex

Table 8-1
Water Bodies within the 15-Mile Tidal Influence Zone
Hunters Point Annex

San Francisco Bay

(North)	(South)
Islais Creek	Yosemite Creek
Coyote Creek	Colma Creek
Richardson Bay	Sea Plane Harbor
Paradise Cove	San Mateo Creek
Harbor Channel	Belmont Slough
Richmond Inner Harbor	Bay Slough
Cerrito Creek	Steinberger Slough
Cordornices Creek	Alameda Creek
Oakland Outer Harbor	Union City Slough
	Mt. Eden Creek
	San Lorenzo Creek
	Flood Control Canal

Oakland Inner Harbor/San Leandro Bay

Lake Merritt	San Leandro Creek
East Creek Slough	

Pacific Ocean

San Pedro Creek	Rodeo Cove
Calera Creek	Tennessee Cove
Milagra Creek	Tennessee Valley Creek

Numerous critical habitats as defined in 50CFR424.02 lie within the tidal influence zone. Reference 4 lists and identifies seven habitat types, including rare or sensitive wetlands and intertidal mudflats, at HPA. The wetlands located along the undeveloped southern shoreline provide the greatest ecological diversity of any habitat at HPA. HPA wetlands are within the zone of tidal influence and are reported to represent the most important salt marsh habitats in the City of San Francisco. Mudflats, located in South Basin and India Basin, occupy the intertidal zone exposed at low tide and provide habitat for invertebrates which are prey for shorebirds and fish.

Marine mammals, including the California sea lion and harbor seal, are routinely observed in San Francisco Bay waters at HPA. Several "California special animals," a term used to refer to taxa of concern, have also been observed at HPA. Table 8-2 lists species which have been seen or may be present at HPA and identifies those classified as threatened and endangered.

Since San Francisco Bay is a seasonal home for birds migrating along the Pacific Flyway, numerous species of migratory birds have been observed at HPA. Table 8-2 presents a list of these waterfowl and shorebirds along with their status, in addition to a list of birds at or near HPA which are listed as important to Audobon societies in San Francisco.

Table 8-2
California Special Plants and Animals &
Threatened and Endangered Species at or near Hunters Point Annex

Species	Common Name	Status at HPA	Designation
California Special Animals			
Ocnorhynchus tshawytscha	Chinook salmon	Observed	SSC (spring run) SE, FT (winter run)
Spirinchus thaleichtys	Longfin smelt	Observed	FC1
Gavia immer	Common loon	Observed	SSC
Pelecanus erythrorhychos	American white pelican	May be present	SSC
Pelecanus occidentalis californicus	California brown pelican	Observed	SE, FE
Phalacrocorax auritus	Double crested cormorant	Observed	SSC
Bucephala islandica	Barrow's goldeneye	Observed	SSC
Charadrius alexandrinus	Snowy plover	May be present	SSC, FC2, SBS, MC
Numenius madagascariensis	Long-billed curlew	Observed	SSC
Larus californicus	California gull	Observed	SSC
Sterna caspia	Caspian tern	May be present	SSC
Sterna elegans	Elegant tern	May be present	SSC
Circus cyaneus	Northern harrier	May be present	SSC, AB
Pandion haliaetus	Osprey	Observed	SSC
Falco peregrinus	Peregrine falcon	Observed	SE, FE
Asio flammeus	Short-eared owl	May be present	SSC, SBS, AB
Athene cunicularia	Burrowing owl	Observed	SSC
Eremophila alpestris	Horned lark	May be present	SSC, FC2
Lanius ludovicianus	Loggerhead shrike	Observed	CSC, FC2
Geothlypis trichas	Common yellowthroat	May be present	SSC, SBS, FC2
Melospiza melodia	Song sparrow	May be present	SSC, FC2
California Special Plants			
Calystegia occidentalis	Morning glory	Present	CSP
Eriogonum nudum	Buck wheat	Present	CSP
Microseris douglasii var. platycarpha	Sunflower	Present	S2S3

Designation Codes:

SSC California Department of Fish and Game Species of Special Concern.
SE Listed as endangered by the State of California.
FE Listed as endangered by the federal government.
FT Listed as threatened by the federal government.
FC1 Category 1 candidate for listing by the U.S. Fish and Wildlife Service (sufficient biological information is available to support a proposal to list taxa as endangered or threatened).
FC2 Category 2 candidate for listing by the U.S. Fish and Wildlife Service (existing information indicates taxa may warrant listing, but substantial biological information necessary to support a proposed rule is lacking).
SBS Sensitive bird species are designated as species that could become threatened or endangered in the foreseeable future by the U.S. Fish and Wildlife Service.
MC Species is a nongame migratory bird of special federal management concern because of documented or apparent population declines, small or restricted populations, and dependence on restricted or vulnerable habitats.
AB Species listed on the Audobon Blue List of birds designated by the National Audobon Society as experiencing a population decline. In addition, the red-shouldered hawk (buteo lineatus--observed at HPA) and horned grebe (podiceps auritus--observed near HPA) are also on the Audobon Blue List.
CSP California Department of Fish and Game Special Plant.
S2S3 Species numbers are between State Status 2 and State Status 3.

San Francisco Bay and its immediate surroundings support no rare or endangered fish species.

Several plant species, designated as "California special plants," are present at HPA. Table 8-2 presents a list of these plants and their status.

Table 8-3 lists sensitive environments within the tidal influence zone of HPA.

Table 8-3
Parks and Reserves within 15 Miles of Hunters Point Annex

San Francisco Bay West

Angel Island State Park
San Francisco Maritime National Historic Park
Agua Vista Park
Candlestick Point State Recreational Area
Coyote Point County Recreational Area
Redwood Shores Ecological Reserve
San Francisco Bay National Wildlife Refuge

San Francisco Bay East

Miller Knox Regional Shoreline
Brooks Island Regional Preserve
Point Isabel Regional Shoreline
Albany Mud Flats Ecological Reserve
Robert Crown Memorial State Beach
M.L. King Regional Shoreline
Oyster Bay Regional Shoreline
Hayward Regional Shoreline

Pacific Ocean

Golden Gate National Recreation Area
Thornton State Beach
Pacifica State Beach
Gray Whale Cove State Beach
Montara State Beach

Located across the bay at the west end of the Robert Crown Memorial State Beach is Crab Cove, a state-protected marine reserve. Crab Cove is one of 13 areas in the state of California which has marine protection. All invertebrates in this area are protected from commercial and sports fishing. The land is owned by the state and is leased to the East Bay Regional Park District, which administers it. In 1980, Crab Cove was designated as a marine reserve by the California State Department of Fish and Game at the request of the East Bay Regional Park District, which was concerned with the growing decline of estuarine species in the area due to illegal harvesting and sports fishing, and which wanted to create an educational program for the public.

No national monuments have been identified within the tidal influence zone.

Wetland frontage within the 15-mile tidal influence zone of concern is estimated at three to four miles.

8.2.3 **Surface Water Pathway Assessment**

Previous sections of this report have established that no drinking water intakes from either surface water or ground water are utilized or could be affected by any potential release via discharge, precipitation run-off, or percolation.

Reference 19 calculates the total body dose to the maximally exposed individual from ingestion of seafood and from recreational use of the water from cobalt-60 and tritium at MINS. These calculations provide a conservative comparison due to far greater workload at MINS than at HPA. Table 7C of Reference 19 lists the annual maximum individual total body doses as 0.000046 mrem from ingestion of seafood and 0.00029 mrem from recreational activities on the shoreline, swimming, and boating.

These calculated values are based on the maximum assumed annual release of 0.001 curie for cobalt-60 and 0.100 curie for tritium. These values conservatively bound the levels of radioactivity in several thousand gallons of unprocessed reactor coolant; such a release has not occurred in over 30 years. Hence, these are very conservative estimates.

According to Reference 7, the total body dose to an individual due to naturally occurring radionuclides contained in the body is about 40 mrem/year. About half of this dose is due to naturally occurring potassium-40. When this value is compared to the dose due to ingestion of seafood, were the seafood contaminated with the maximum conceivable level of NNPP radioactivity, it is seen that the dose due to consumption of seafood is about 0.00023 percent of the 20 mrem from potassium-40. A similar comparison shows that the recreational dose is about 0.0015 percent of that due to potassium-40.

The Navy concludes that radioactivity in surface waters will not damage sensitive environments as described by Reference 23. As discussed above and in Section 6, no water, marine biota, or sediment samples have shown levels of cobalt-60, nor have any shorelines within the littoral zone accumulated any radioactivity associated with the NNPP. This evidence supports the conclusion that there has been no environmentally detrimental release of radioactivity to surface waters surrounding Hunters Point Annex.

8.3 **Soil Exposure Pathway**

The soil exposure pathway considers potential exposure threats to people on or near the site who may come into contact with a hazardous substance via dermal exposure, soil ingestion, or plant uptake into the human food chain.

HPA was actively engaged in NNPP work from 1985 until 1989, when a nuclear-powered ship was last serviced in Drydock 4. As such, there were ships containing radioactivity associated with this work at the shipyard. The radiological controls applied to prevent contamination of workers and the environment are discussed in other sections of this report.

For areas and facilities other than those discussed above, this report concludes that there is no likelihood for exposure to humans or to the environment. This conclusion is based on the following:

- Perimeter radiation levels have consistently been comparable to background radiation levels.
- Shoreline surveys found no radionuclides along the shore attributable to NNPP activities.
- There has been no solid NNPP radioactive waste disposal on or near Naval property, as documented by regulatory prohibition, review of historical disposal records, and review of measured radiation levels.

Since the above evidence would result in a "no likelihood of exposure" finding, the other elements of the soil exposure pathway do not need to be evaluated.

8.3.1 **Release Mechanisms Affecting Soil**

The release mechanisms discussed in the air pathway section could deposit radioactivity in the soil of affected areas. Radioactive liquid spills to the soil would be much more localized and concentrated than soil contamination resulting from low level airborne radioactivity releases. Liquid spills with the highest potential for reaching the soil are related to activities performed outside of radiological work areas. These activities include connections of tanks to ships, tank-to-tank transfers, and the movement of smaller liquid containers such as plastic bottles. None of these activities were performed near any unprotected soil; they were performed aboard ship or inside Drydock 4. Spills of radioactive liquids inside Drydock 4 would generally be contained within the drydock but could reach the soil through cracks or by leaching through porous materials such as concrete.

The most likely potential sources of NNPP radioactivity at HPA are berthing areas of nuclear ships and vessels serviced in Drydock 4. As stated previously, all radioactive material is packaged in accordance with Department of Transportation shipping requirements prior to being removed from a ship for transfer to other facilities.

In the event of a fire aboard a ship or at a temporary radioactive material storage area in Drydock 4, the large volumes of water needed to control the fire could result in the transport of radioactive materials into the soil. No such events occurred.

8.3.2 **Soil Exposure Targets**

No residences, schools, or daycare facilities are located within 200 feet of any potential source of NNPP radioactivity.

Section 3 presents details of the population distribution near and around HPA. Although no one physically resides within HPA, the Bayview/Hunters Point housing area is located immediately west and northwest of the site, with houses located by the HPA entrance gate (about one-half mile from Drydock 4).

A Preliminary Assessment conducted by the U.S. Environmental Protection Agency between 1987 and 1988 (during the period of NNPP work at the site) reported approximately 1000 workers at HPA.

Wetlands and mudflats have been identified as rare or sensitive habitats at HPA.

There is no land resource use for commercial agriculture, commercial silviculture, or commercial livestock production or grazing within a four-mile radius of the shipyard.

8.3.3 **Soil Exposure Pathway Assessment**

The ground deposition element in the airborne pathway of Reference 19 is directly relatable to the soil exposure pathway. For this calculation, only cobalt-60 is considered since, of the radionuclides listed in Table 8-1 of Reference 19, it is the only particulate. Although most noble gases have particulate daughters, the transport of the gaseous parent disperses and dilutes the eventual dry deposition and rain-out of particulate daughters to such an extent that their dose contribution is negligible.

Table A-1 of Reference 22 lists the annual total body dose due to natural sources in the vicinity of HPA as approximately 63 mrem (7.2 μR/hr): 28 mrem (3.2 μR/hr) is due to terrestrial sources of natural radioactivity and 35 mrem (4.0 μR/hr) is due to cosmic radiation. Reference 22 is cited extensively in Reference 7 as a continuing source of data for natural background radiation exposure estimates. This value is consistent with data presented in Table 7E of Reference 19 and with surveys performed by the EPA.

The maximum individual annual total body dose for HPA due to soil exposure from 0.001 curie of cobalt-60 ground deposition would be 0.064 mrem as listed in Table 7B of Reference 19. Table 5-3 of this assessment shows that the calculated maximum possible airborne release of NNPP radioactivity, a value based on the detection capability of the counting equipment, occurred in 1977 and totaled 5.2×10^{-6} curie. Presuming all this activity is deposited on the soil of interest, this is still a factor of about 200 less than the 0.001 curie used for Reference 19 calculations. Hence, the actual maximum individual total body dose through the soil pathway would be 0.0003 mrem/yr. This is about 0.001 percent of the estimated natural terrestrial background, or alternatively, this yearly dose is about one tenth of the hourly exposure from natural sources of radioactivity from the earth.

The Navy concludes there has been no adverse impact on human health or the environment due to the soil exposure pathway.

8.4 **Air Pathway**

The air pathway considers potential exposure threats to people and to sensitive environments via migration through the air.

As discussed in Section 5, air discharged from radiological work facilities contains radioactivity at or below an equivalent amount of environmental air containing naturally occurring radioactivity. Where the same filtering procedures are used and more sensitive analyses are available, such as at MINS, data consistently demonstrate that air discharged from radiological work facilities contains less radioactivity than background air (e.g., see the MINS HRA). Since air leaving radiological facilities contains equivalent or lower than background concentrations, the likelihood of an airborne release is very low. When quality analytical evidence shows that exhaust air from a facility is cleaner than environmental air and the facility has a long history of air control measures, such as HEPA filtered and monitored exhausts, no individual on-site or within the 4-mile radius of concern is being exposed.

Other potential sources of airborne radioactivity, such as from contaminated soil or spills of contaminated liquids, have been discussed in other sections of this report. Based on the lack of detectable soil contamination, and the immediate containment and recovery actions taken for spills, the Navy considers these potential sources of airborne radioactivity have been eliminated from consideration.

8.4.1 **Release Mechanisms Affecting the Air**

The methods employed to prevent the release of radioactivity into the atmosphere were discussed in Section 4.4 and have proven to be extremely effective. Nevertheless, consideration of atmospheric releases is necessary since such releases would potentially allow radioactivity to contact the soil and surface water. Some mechanisms that could cause an atmospheric release of radioactivity follow.

8.4.1.1 **Potential Releases from Ventilation Systems**

Facilities that are used for radioactive work or work with radioactive materials are potential sources of airborne radioactivity. High efficiency particulate air (HEPA) filtered ventilation systems are used in these facilities and could fail before or during work and allow radioactive particulates to enter the atmosphere. Potential failure modes for HEPA filters include: improper installation, damage during installation or use, improper differential pressure testing, or exceeding HEPA filter capacity. In addition, duct work associated with these ventilation systems could fail or become damaged causing an uncontrolled release.

8.4.1.2 **Potential Releases from Storage Areas**

The primary atmospheric release potential from radioactive material storage areas would be a fire. NNPP regulations specify that buildings where radioactive materials are stored shall be constructed and equipped with fire protection systems in accordance with Reference 24. These provisions include building construction, fire detection and alarm systems, automatic sprinkler systems, portable fire extinguishers, and fire hydrants. In addition to structure requirements, NNPP regulations: require that materials be stored in fire retardant containers; prohibit welding, burning, or other operations that could cause a fire without prior authorization; and require periodic inspections and fire drills.

Another potential release mechanism is the possibility of the loss of containment for items being stored, including tears in packaging material.

8.4.1.3 **Potential Releases from Collection Tanks**

Tanks containing radioactive liquid effluent present a potential for atmospheric release. If a tank were to rupture or leak, evaporation of the liquid could allow radioactive particles to become airborne. Rupture or leakage could result from corrosion of the tank, excessive pressure build-up, or human error in valve positioning. A release could also occur if a tank were to overflow during a liquid transfer.

8.4.2 **Air Targets**

Target populations under the air pathway consist of people who reside, work, or go to school within the 4-mile target distance limit around the site. Preliminary Assessment air pathway targets also include sensitive environments and resources.

Targets are evaluated on the basis of their distance from the site. Those persons closest to the site are most likely to be affected and are evaluated as primary targets. The nearest individual would be an on-site worker.

Like the other migration pathways, a release must be suspected in order to score primary targets for the air pathway. Releases to the air pathway, however, are fundamentally different from releases to the other migration pathways. Depending on the wind, air releases may disperse in any direction. Therefore, when a release is suspected, all populations and sensitive environments out to and including the 1/4-mile distance category are evaluated and scored as primary targets. Because air releases are quickly diluted in the atmosphere, targets beyond the 1/4-mile distance are evaluated as secondary targets.

As with other migration pathways when a release is not suspected, the residential, student, and worker population within the entire 4-mile target distance limit is evaluated as the secondary target population. The population distribution for the secondary target population is given in Section 3.

Sensitive environments are defined as terrestrial or aquatic resources, fragile natural settings, or other areas with unique or highly-valued environmental or cultural features.

Typically, areas that fall within the definition of "sensitive environment" are established and/or protected by State or Federal law. Examples include National Parks, National Monuments, habitats of threatened or endangered species, wildlife refuges, and wetlands. Sensitive environments are discussed in Section 8.2.2.

As discussed in Section 3.3.3.3, HPA habitats include wetland areas and mudflats. Except for wetlands and mudflats, there are no sensitive environments within 1/2 mile of HPA.

The resources factor accounts for land uses around the site that may be impacted by release to the air. While commercial agriculture and commercial silviculture (e.g., tree farming, timber production, and logging) do not occur within four miles of HPA, recreational areas are located nearby and throughout the Bay Area.

As discussed in previous pathways, numerous sensitive environments surround HPA, and several wetland areas and wildlife refuges lie within the Bay Area.

8.4.3 **Air Pathway Assessment**

Of the pathways considered in Reference 19, the plume immersion and inhalation pathways best fit the model of Reference 23.

Table 7B of Reference 19 presents the results of calculated radiation dose estimates for immersion and inhalation at Mare Island Naval Shipyard (used to provide a conservative comparison). For comparative purposes, the total body dose to the maximally exposed individual is used in all cases.

Reference 19 calculates an annual total body dose of 0.056 mrem for immersion and 0.0032 mrem for inhalation, for radionuclides of NNPP interest. This gives a combined dose of 0.0592 mrem for this pathway. For inhalation, only cobalt-60 and carbon-14 contribute significantly to exposure. For immersion, cobalt-60, carbon-14, tritium, and all fission product noble gases as listed in Table 7A of Reference 19 are considered.

This represents a maximum value since the assumed releases of Table 7A (Reference 19) are significantly higher than a calculated maximum possible release. For example, for cobalt-60, the primary radionuclide of interest for NNPP nuclear facilities, the calculations are based on 0.001 curie per year. Table 5-3 shows that the maximum possible release occurred in 1977 and totaled less than 5.2×10^{-6} curie or a factor of about 200 less.

Comparing the Reference 19 combined dose of 0.0592 mrem/yr to the dose from natural sources of radiation listed in a report published by the National Council on Radiation Protection and Measurements (Reference 7), the calculated combined dose is about 0.03 percent of that due to airborne natural background radioactivity (primarily radon). When the actual release values for radiological work at HPA are factored in, the comparative percentage becomes vanishingly small.

These results and comparisons provide evidence that the airborne exposure to any potential target due to NNPP activities at HPA is insignificant.

9.0 **CONCLUSIONS**

Evaluation of the information and analytical data presented in this HRA leads to the conclusion that past activities at Hunters Point Annex associated with work on Naval nuclear propulsion plants have had no adverse impact on the human population or ecosystem of the region.

Of all the radiological parameters monitored and reported as part of the longstanding monitoring of the radiological environment, no cobalt-60 or other radionuclides associated with Naval nuclear propulsion plants have been detected.

The findings and conclusions of the Environmental Protection Agency survey reported in 1989 fully support the data and conclusions of this assessment. The EPA conclusions were quoted in Section 6.1.1 and are repeated in part below:

> "Based on this survey, operations related to nuclear-powered warship activities have contributed no detectable radioactivity to the harbors at Mare Island, Alameda, and Hunters Point. Thus, under present conditions Naval operations within these harbors pose no radiological health problem to the public."

The Navy no longer performs any NNPP maintenance at Hunters Point Annex. Hence, no further environmental monitoring as discussed in this HRA is planned. Within the framework of the CERCLA process, no further action is warranted regarding radioactivity associated with the Naval Nuclear Propulsion Program at Hunters Point Annex.

GLOSSARY

Aquifer: A saturated subsurface zone from which drinking water is drawn.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Legislation that established the Federal Superfund for response to uncontrolled releases of hazardous substances to the environment.

CERCLIS: CERCLA Information System. EPA's computerized inventory and tracking system for potential hazardous waste sites.

Coastal Tidal Waters: Surface waterbody type that includes embayments, harbors, sounds, estuaries, back bays, etc. Such water bodies are in the interval seaward from the mouths of rivers and landward from the 12-mile baseline marking the transition to the ocean water body type.

curie: Abbreviated Ci. A unit of measure of the amount of radioactivity equal to 3.7×10^{10} disintegrations per second or 2.22×10^{12} disintegrations per minute.

EPA: U.S. Environmental Protection Agency. The Federal agency responsible for action under CERCLA.

Factor: The basic element of site assessment requiring data collection and evaluation for scoring purposes.

FFA: Federal Facility Agreement. An agreement among the EPA, state, and site detailing the extent and schedule for remedial actions.

Fishery: An area of a surface water body from which food chain organisms are taken or could be taken for human consumption on a subsistence, sporting, or commercial basis. Food chain organisms include fish, shellfish, crustaceans, amphibians, and amphibious reptiles.

G-RAM: General Radioactive Material. Radioactive materials that are not associated with the NNPP.

HEPA Filter: High Efficiency Particulate Air Filter. A filter that will remove 99.97% of 0.3 micron particulates from an air system.

HPA: Hunters Point Annex.

GLOSSARY (continued)

HRA: Historical Radiological Assessment. A compilation of site historical radiological data derived from the site environmental monitoring program and other records. This document is intended to be an integral part of a FFA.

HRS: Hazard Ranking System. EPA's principal mechanism for placing sites on the NPL.

KAPL: Knolls Atomic Power Laboratory; a Department of Energy (DOE) laboratory.

kcpm: Thousand counts per minute.

MDA: Minimum Detectable Activity.

micro: Abbreviated μ. A prefix denoting a one-millionth part (10^{-6}).

micron: A millionth of a meter (10^{-6}m).

milli: Abbreviated m. A prefix denoting a one-thousandth part (10^{-3}).

MINS: Mare Island Naval Shipyard.

Mudflat: An intertidal (or periodically exposed) expanse of mud, characterized by mobile fine sediments and typically rich in fauna.

NAS: Naval Air Station.

NNPP: Naval Nuclear Propulsion Program. A joint Navy/Department of Energy program to design, build, operate, maintain, and oversee operation of Naval nuclear-powered ships and associated support facilities.

No Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is not likely to have been released to the environment.

NPL: National Priorities List. Under the Superfund program, the list of sites of releases and potential releases of hazardous substances, pollutants, and contaminants that appear to pose the greatest threat to public health, welfare, and the environment.

GLOSSARY (continued)

PA: Preliminary Assessment. Initial stage of site assessment under CERCLA; designed to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.

pico: Abbreviated p. A prefix denoting a one-trillionth part (10^{-12}).

R: Roentgen. A unit of exposure. For cobalt-60 radiation, a roentgen and a rem are considered to be equivalent.

rem: Roentgen Equivalent Man. A measure of radiation dose.

SARA: Superfund Amendments and Reauthorization Act of 1986. Legislation which extended the Federal Superfund Program and mandated revision to the HRS.

Surface Water: A naturally-occurring, perennial water body; also, some artificially-made and/or intermittently-flowing water bodies.

Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is likely to have been released to the environment.

Target: A physical or environmental receptor that is within the target distance limit for a particular pathway. Targets may include wells and surface water intakes supplying drinking water, fisheries, sensitive environments, and resources.

Target Distance Limit: The maximum distance over which targets are evaluated. The target distance limit varies by pathway; ground water and air pathways -- a 4-mile radius around the site; surface water pathway -- 15 miles downstream from the probable point of entry to surface water; soil exposure pathway -- 200 feet (for the resident population threat) and 1 mile (for the nearby population threat) from areas of known or suspected contamination.

Target Population: The human population associated with the site and/or its targets. Target populations consist of those people who: use target wells or surface water intakes supplying drinking water; consume food chain species taken from target fisheries; or are regularly present on the site or within target distance limits.

Terrestrial Sensitive Environment: A terrestrial resource, fragile natural setting, or other area with unique or highly-valued environmental or cultural features.

TLD: Thermoluminescent dosimeter. A device for measuring gamma radiation exposure.

Wetland: A type of sensitive environment characterized as an area that is sufficiently inundated or saturated by surface or ground water to support vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Worker: Under the soil exposure pathway, a person who is employed on a full- or part-time basis on the property on which the site is located. Under all other pathways, a person whose place of full- or part-time employment is within the target distance limit.

<: Less than.

>: Greater than.

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